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Vol. 8 October, 1953 No. 2

Department of Agriculture, Stock and Fisheries,
Port Moresby

FORMER ISSUES OF *GAZETTE*

The following numbers of the *Agricultural Gazette* have been issued :

New Guinea Agricultural Gazette—

Volume 1, Number 1.

Volume 2, Numbers 1, 2 and 3.

Volume 3, Numbers 1 and 2.

Volume 4, Numbers 1, 2, 3 and 4.

Volume 5, Numbers 1, 2 and 3.

Volume 6, Numbers 1, 2 and 3.

Volume 7, Numbers 1, 2, 3 and 4.

The Papua and New Guinea Agricultural Gazette—

Volume 8, Number 1.

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The Papua and New Guinea Agricultural Gazette (New Series) will be published quarterly, commencing with the quarter July to October, 1953. It will be noted that the name of the *Gazette* has been changed. The publication will follow the form of the prewar *New Guinea Agricultural Gazette* and will deal with recent advancement in tropical agriculture and act as an extension medium for the dissemination of agricultural information to the Territory planting and farming community.

Members of the public are invited to submit items of tropical and general interest to agriculturalists in the Territory. Articles from interested persons outside the Territory will be appreciated.

The first Volume (1953-1954) will be issued free of charge to recognized Institutions and Organizations dealing with agriculture and related subjects; thereafter issues to such subscribers will be on either a reciprocal or subscription basis.

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Brigadier D. M. Cleland, C.B.E.

The

Papua and New Guinea

Agricultural Gazette

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STUDY OF THE RELATIONSHIP BETWEEN CACAO YIELD AND RAINFALL

By L. A. Bridgland, B.Sc. (Agr.), D.T.A. *

(The data used in this study have been taken from observations on a progeny testing trial which forms part of the Cacao Improvement Programme at the Lowlands Experimental Station, Keravat. The trial is laid down as a randomized block with four replications. Each replication contains ten plots of forty-six trees, the trees in each plot being the progeny of one of ten field selections made in 1947.

Seeds for the progeny used were planted in the nursery in December, 1947, and transferred to the field in March, 1948. Seedlings were planted 15 ft. x 15 ft. on the square and have had orthodox *Leucaena glauca* shade. The total numerical yield of pods for all forty plots was used in the present study.)

Method.—

The cacao pods are harvested roughly every twenty-one days but this period is not exact and not quite regular. Yields, therefore, had to be adjusted to a monthly basis by calculation. This was done as follows :—

Suppose the cacao pods were harvested on 7th March and again on the 1st April. The period between the harvest is 25 days. Suppose that the yield on 1st April was 2,904 pods, i.e., the average daily yield from 7th March to 1st April = 2,904 ÷ 5 = 116.1 pods. Of the 25 days concerned, 24 occurred in March and one in April. Thus of the 2,904 pods yielded 116.1 × 24 can be allocated to March and 116.1 × 1 can be allocated to April. By this method yields were calculated on a monthly basis and graphed (Figure 1). Monthly rainfall figures were also graphed (Figure 2). From an inspection of these graphs in relation to each other, it seemed possible that the yield at any point on the time scale was positively correlated with the rainfall three months before and negatively correlated with the rainfall about five months before.

Correlation coefficients were therefore calculated for—

1. Yield with rainfall 3 months before.
2. Yield with rainfall 4 months before.
3. Yield with rainfall 5 months before.
4. Yield with rainfall 6 months before.

Results.—

1. A correlation coefficient of + 0.58 was obtained. This is highly significant ($P = 0.01$).
2. A correlation coefficient of —0.69 was obtained. This is highly significant ($P = 0.001$).
3. A correlation coefficient of —0.79 was obtained. This is highly significant ($P = 0.001$).
4. A correlation coefficient of —0.19 was obtained. This is not significant ($P = 0.3$).

Discussion.—

It can be seen from the following figures that it usually takes six months for a ripe pod to be produced from the time of pollination.

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Time for Pollination to Maturity.—

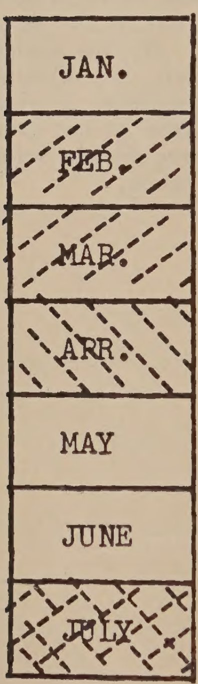
(Figures taken from data re self-pollination.)

Pod No.	Date Pollinated	Date Harvested	No. Days	Month (30) days
1	14.11.1951	2.6.1952	200	6.6
2	15.11.1951	2.6.1952	199	6.6
3	23.11.1951	2.6.1952	191	6.4
4	24.11.1951	2.6.1952	190	6.3
5	28.11.1951	2.6.1952	186	6.2
6	7.12.1951	2.6.1952	177	5.9
7	18.12.1951	2.6.1952	166	5.5
8	20.12.1951	2.6.1952	164	5.5
9	21.12.1951	2.6.1952	163	5.4
10	28.11.1951	2.6.1952	186	6.2
11	1.12.1951	2.6.1952	184	6.1
12	12.1.1952	30.6.1952	169	5 6
13	1.12.1951	2.6.1952	184	6.1
14	7.2.1952	14.8.1952	188	6.3

Total = 2,547.

Mean = 182 days or 6.06 months.

The results can be discussed better with an hypothetical example.



(Figure 3)

The yield in July is positively correlated with rainfall in April and negatively correlated with rainfall in February and March. There is no relationship between yield in July and rainfall in January (Figure 3).

It can be seen that pods harvested in July will have resulted from pollination of flowers in January. Thus, it appears that :—

1. There is no regular relationship between rainfall at the time of pollination and yield.
2. There is no regular relationship between rainfall for the first 3-4 weeks after pollination and yield.
3. There is a distinct negative correlation between rainfall for the period 4-12 weeks after pollination and yield.
4. There is a distinct positive correlation between rainfall for the period 12-16 weeks after pollination and yield.

1. *Effect of Rainfall on Pollination.*—

Let us consider first, the evidence that rainfall does not appear to influence pollination in any regular manner. It cannot be concluded that rainfall never has any influence on pollination.

If the rainfall graph is superimposed on the yield graph so that yield corresponds with the rainfall six months previously, it is apparent that there is no regular relationship between the two lines. This is proven by one of the correlation tests. However, it can be seen that sometimes there appears to be a negative correlation and sometimes a positive correlation. This could mean nothing at all or it could mean that two or more interacting factors

(of which rainfall is one) determine the amount of setting. The most that can be said at present is that there is no evidence to suggest that rainfall at the time of pollination exerts a significant effect on yield. Pollination does not appear to be the limiting factor.

2. *Effect of Rainfall for the First 3-4 Weeks after Pollination.*—

Let us consider the evidence that rainfall for the first 3-4 weeks after pollination does not effect yield in any regular manner. That is, that the extent of cherelle wilt is not effected in a regular manner by rainfall for the

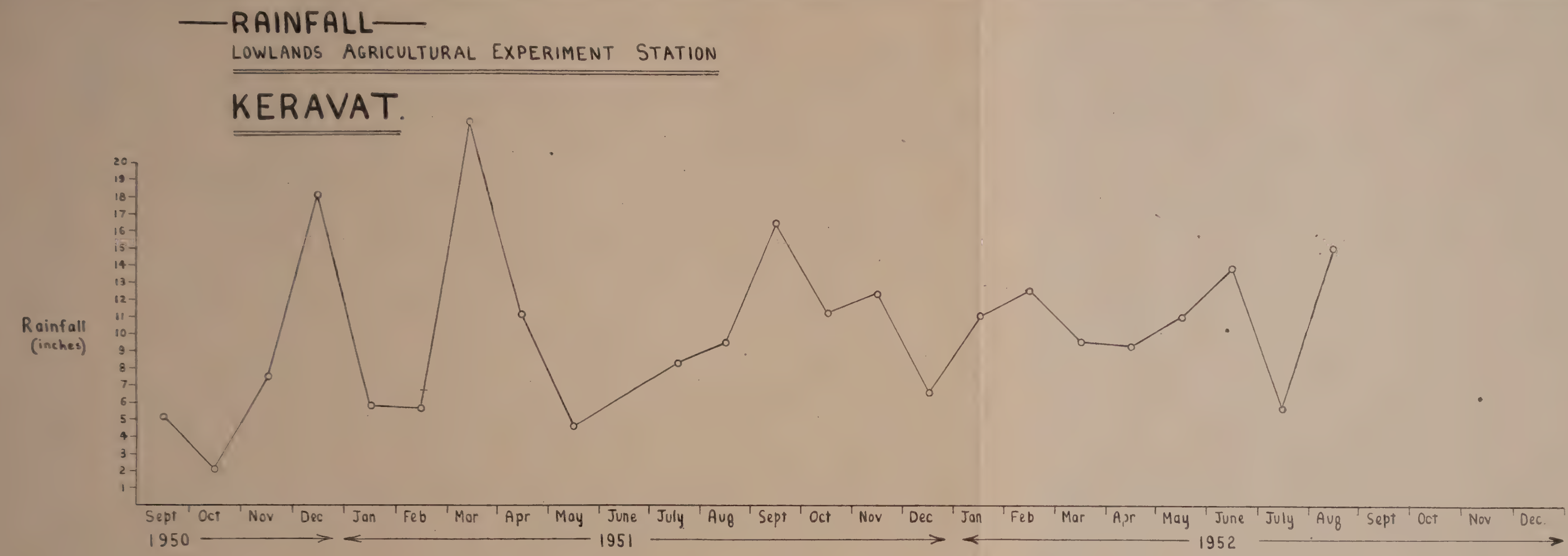


Fig. 2

A count of this nature is of no particular value as many of the cherelles counted may have been adhering to the tree for some time. It is proposed to carry out a systematic count over a twelve-month period, in order to find out whether the above explanation of results is correct. In the meantime, the figures given in the above table appear to corroborate the explanation given. Another significant fact is that of all the dead cherelles counted 90 per cent. were estimated to be from 3-8 weeks old.

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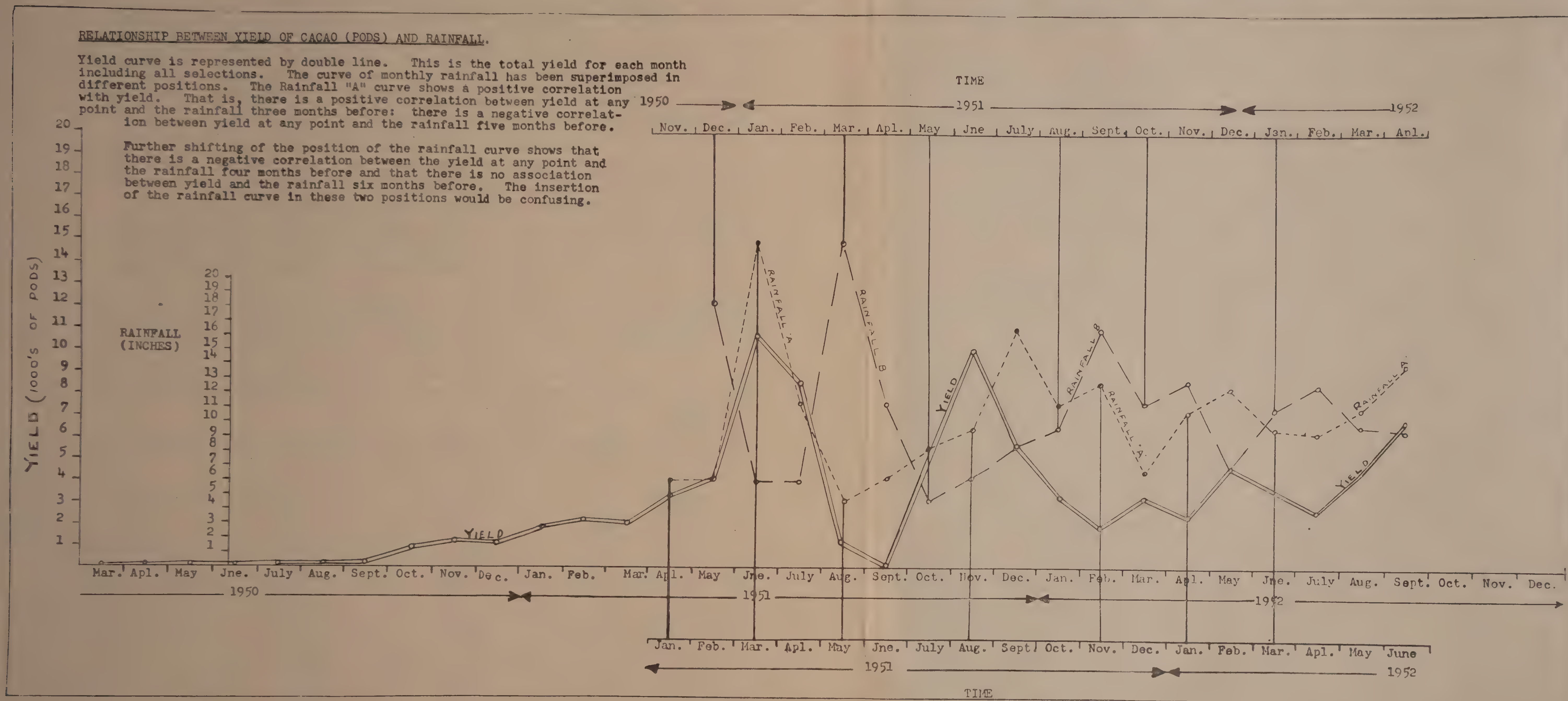

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Time for Pollination to Maturity.—

(Figures taken from data re self-pollination.)

Pod No.	Date Pollinated	Date Harvested	No. Days	Month (30) days
1	14.11.1951	2.6.1952	200	6.6
2	15.11.1951	2.6.1952	199	6.6
3	23.11.1951	2.6.1952	191	6.4

(Figure 3)

not appear to influence pollination in any regular manner. It cannot be concluded that rainfall never has any influence on pollination.

If the rainfall graph is superimposed on the yield graph so that yield corresponds with the rainfall six months previously, it is apparent that there is no regular relationship between the two lines. This is proven by one of the correlation tests. However, it can be seen that sometimes there appears to be a negative correlation and sometimes a positive correlation. This could mean nothing at all or it could mean that two or more interacting factors

(of which rainfall is one) determine the amount of setting. The most that can be said at present is that there is no evidence to suggest that rainfall at the time of pollination exerts a significant effect on yield. Pollination does not appear to be the limiting factor.

2. *Effect of Rainfall for the First 3-4 Weeks after Pollination.*—

Let us consider the evidence that rainfall for the first 3-4 weeks after pollination does not effect yield in any regular manner. That is, that the extent of cherelle wilt is not effected in a regular manner by rainfall for the first 3-4 weeks following pollination. There are several possible explanations of this; (Assuming that cherelle wilt is largely caused by pathogens) :—

(*a*) That for one reason or another the very young cherelles escape infection for the first few weeks of development;

(*b*) That the very young cherelles are resistant to the pathogen(s);

(*c*) That infection of the young cherelles by the pathogen(s) depends on prior inoculation by sucking and biting insects, it being assumed that cherelles largely escape insect attack on account of their size until they are over three weeks old; and

(*d*) That the cherelles are able to outgrow the pathogen for the first 3-4 weeks, after pollination irrespective of rainfall. Thereafter high rainfall leads to ideal growing conditions for the pathogen(s) so that they are able to kill the cherelle and low rainfall leads to poor growing conditions for the pathogens so that the cherelle is still able to outgrow the pathogen(s).

Monthly figures showing the extent of cherelle wilt cannot be produced to corroborate this explanation, but field observations agree with the findings. At the time of writing there have been five consecutive wet overcast days.

A random selection of 18 trees gave the following counts :—

	Tree No.	No. Dead Cherelles	No. Healthy Cherelles
	1	22	33
Date of Count—	2	6	9
28th November, 1952	3	8	18
	4	7	3
Rainfall (points)—	5	47	4
21st November, 1952 15	6	18	2
22nd November, 1952 9	7	28	5
23rd November, 1952 82	8	5	4
24th November, 1952 304	9	2	0
25th November, 1952 55	10	1	0
	11	27	17
	12	31	8
	13	15	3
	14	3	52
	15	32	0
	16	28	5
	17	14	2
	18	38	8

A count of this nature is of no particular value as many of the cherelles counted may have been adhering to the tree for some time. It is proposed to carry out a systematic count over a twelve-month period, in order to find out whether the above explanation of results is correct. In the meantime, the figures given in the above table appear to corroborate the explanation given. Another significant fact is that of all the dead cherelles counted 90 per cent. were estimated to be from 3-8 weeks old.

3. *Effect of Rainfall for the Period 4-12 Weeks after Pollination.*—

There appears to be indisputable evidence that the principal factor limiting yield is the rainfall during the period 4-12 weeks after pollination. The most obvious explanation of this is that high rainfall during this period leads to a high rate of infection of cherelles by such organisms as *Phytophthora, Colletotrichum* and *Diplodia.* This leads to excessive cherelle wilt which results in a depression of yield 4-5 months later. It would be difficult to interpret the results any other way. It seems unlikely that the excessive cherelle wilt during high rainfall could have a purely physiological explanation.

4. *Effect of Rainfall for the Period 12-16 Weeks after Pollination.*—

It was found that rainfall during this period is positively correlated with yield. Bearing in mind the fact that yield is measured by the number of pods produced, there are two possible explanations of this result :—

(*a*) That high rainfall at this stage leads to a very rapid increase in the growth rate of pods which have survived the first 12 weeks so that once again the pathogen(s) are simply outgrown. Low rainfall during this period would give the pathogen(s) a decided advantage resulting in further loss of young pods. On this explanation, therefore, after the age of 12 weeks, the higher the rainfall, the lower the loss of pods. Field observations indicate that pods are still lost after the age of 12 weeks.

(*b*) After the age of 12 weeks, pods are most resistant to the pathogens and that the time required for maturation of the pod is directly proportioned to the rainfall for the period 12-16 weeks after pollination. It will be seen from the figures given that the time from pollination to ripe pod varies from 5½ to 6½ months.

JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY

Taking flowers pollinated in January, a certain percentage will have survived at the end of March depending on the rainfall during February and March.

It is suggested that the rainfall in April may determine whether the maturation period will be 5½ or 6½ months or somewhere in between. If the rainfall in April is high, the maturation period is reduced to about 5½ months and many of the pods which would normally have ripened in August would now ripen in July, thereby increasing the yield for this month. Conversely, if the rainfall in April is low, the maturation period is increased to 6½ months and many of the pods which would normally have ripened in July would now ripen in August thereby depressing the yield for July.

Although both of the above explanations appear to be feasible, the latter explanation appears to be the more satisfactory.

Summary.—

If it can be accepted that any influence of rainfall on yield for the period 4-12 weeks after pollination of the flowers, is exerted by a direct influence on pathogenic organisms causing cherelle wilt, the following conclusions can be drawn :—

(1) There is no evidence to support the view that rainfall has a regular significant effect on pollination.

(2) There is no evidence to support the view that pollination is an important factor limiting yield.

(3) There is relatively little cherelle wilt for the first 3-4 weeks after pollination irrespective of rainfall.

(4) For the period 4-12 weeks after pollination, high rainfall results in excessive cherelle wilt and low rainfall results in little cherelle wilt.

(5) For the period 12-16 weeks after pollination, high rainfall has the effect of increasing yield and the corollary is also true.

RELEVANT RAINFALL AND YIELD FIGURES.

Year	Month	Yield (100's pods)	Rainfall (points)	No. days on which rain fell.
1950	September	....	532	9
	October	....	210	8
	November	....	778	12
	December	....	1826	17
1951	January	....	590	18
	February	....	566	10
	March	....	2242	25
	April	33.1	1124	11
	May	40.9	453	12
	June	107.0	613	16
	July	84.0	823	20
	August	10.7	949	18
	September	0.08	1654	19
	October	62.3	1131	17
	November	99.8	1288	19
	December	54.0	658	11
1952	January	32.4	1089	10
	February	17.7	1249	18
	March	31.6	955	19
	April	23.2	934	16
	May	44.0	1090	15
	June	34.8	1397	23
	July	25.9	565	19
	August	42.0	....	....
	September	66.2	....	....

RELATIONSHIP BETWEEN MONTHLY YIELD OF CACAO.
PODS AND RAINFALL FOR THE THIRD PREVIOUS MONTH.

Month	(inches) Rainfall (X)	Month	(100's pods) Yield (Y)	X^2	Y^2	XY
Jan., ... '51	5.90	Apr., ... '51	33.1	34.81	1,095.61	195.29
Feb., ... '51	5.66	May, ... '51	40.9	32.04	1,672.81	231.49
Mar., ... '51	22.40	June, ... '51	107.0	501.76	11,449.00	2,396.80
Apr., ... '51	11.20	July, ... '51	84.4	125.44	7,123.36	945.28
May, ... '51	4.53	Aug., ... '51	10.7	20.52	114.49	48.47
June, ... '51	6.13	Sept., ... '51	.08	37.58	0.01	0.49
July, ... '51	8.23	Oct., ... '51	62.3	67.73	3,881.29	512.73
Aug., ... '51	9.49	Nov., ... '51	99.8	90.06	9,960.04	947.10
Sept., ... '51	16.50	Dec., ... '51	54.00	272.25	2,916.00	891.00
Oct., ... '51	11.30	Jan., ... '52	32.4	127.69	1,049.76	366.12
Nov., ... '51	12.90	Feb., ... '52	17.7	166.41	313.29	228.33
Dec., ... '51	6.58	Mar., ... '52	31.6	43.30	998.56	207.93
Jan., ... '52	10.90	Apr., ... '52	23.2	118.81	538.24	252.88
Feb., ... '52	12.50	May, ... '52	44.0	156.25	1,936.00	550.00
Mar., ... '52	9.55	June, ... '52	34.8	91.20	1,211.04	332.34
Apr., ... '52	9.34	July, ... '52	25.9	87.24	670.81	241.91
May, ... '52	10.90	Aug., ... '52	42.0	118.81	1,764.00	457.80
June, ... '52	14.00	Sept., ... '52	66.2	196.00	4,382.44	926.80
Total	188.01	....	810.08	2,287.90	51,076.75	9,732.76

$N = 18$ $\quad \overline{X} = 10.45 \quad (SX)^2 = 35{,}347.76$

$\overline{Y} = 45.00 \quad (SY)^2 = 656{,}229.61$

$$r_{XY} = \frac{NS(XY) - SX.SY}{\sqrt{[NS(X)^2 - (SX)^2]\ [NS(Y)^2 - (SY)^2]}}$$

$$= \frac{18 \times 9732.76 - 188.01 \times 810.08}{\sqrt{(18 \times 2{,}287.90 - 35{,}347.76)\ (18 \times 51076.75 - 656{,}229.61)}}$$

$$= + \ 0.584$$

$$t = \frac{r\sqrt{N-2}}{\sqrt{1 - r^2}} = \frac{0.584\sqrt{16}}{1 - 0.341056}$$

$$= 2.88$$

$N = 18 \qquad P = .01$

Conclusion—

There is a highly significant positive correlation between yield of cacao pods and the rainfall during the third previous month.

RELATIONSHIP BETWEEN YIELD OF CACAO PODS AND RAINFALL FOR THE FOURTH PREVIOUS MONTH.

Month	Rainfall X	X^2	Month	Yield Y	Y^2	XY
Dec., ... '50	18.30	334.89	Apr., ... '51	33.1	1,095.61	605.73
Jan., ... '51	5.90	34.81	May, ... '51	40.9	1,672.81	241.31
Feb., ... '51	5.66	32.04	June, ... '51	107.0	11,449.00	605.62
Mar., ... '51	22.40	501.76	July, ... '51	84.0	7.123.36	188.16
Apr., ... '51	11.20	125.44	Aug., ... '51	10.7	114.49	119.84
May, ... '51	4.53	20.52	Sept., ... '51	0.08	0.01	0.40
June, ... '51	6.13	37.58	Oct., ... '51	62.3	3,881.29	381.90
July, ... '51	8.23	67.73	Nov., ... '51	99.8	9,960.04	821.35
Aug., ... '51	9.49	90.06	Dec., ... '51	54.0	2,916.00	512.46
Sept., ... '51	16.50	272.25	Jan., ... '52	32.4	1,049.76	534.60
Oct., ... '51	11.30	127.69	Feb., ... '52	17.7	313.29	200.01
Nov., ... '51	12.90	166.41	Mar. .... '52	31.6	998.56	407.64
Dec., ... '51	6.58	43.30	Apr., ... '52	23.2	538.24	152.66
Jan., ... '52	10.90	118.81	May, ... '52	44.0	1,936.00	479.60
Feb., ... '52	12.50	156.25	June, ... '52	34.8	1,211.04	435.00
Mar. .... '52	9.55	91.20	July, ... '52	25.9	670.81	247.35
Apr., ... '52	9.34	87.24	Aug., ... '52	42.0	1,764.00	392.28
May, ... '52	10.90	118.81	Sept., ... '52	66.2	4,384.44	721.58

$SX = 192.31 \qquad S(X)^2 = 2426.79 \qquad SY = 810.08$

$S(Y)^2 = 51{,}076.75 \qquad S(XY) = 7{,}047.49$

$(SX)^2 = 36{,}983.14 \qquad (SY)^2 = 656{,}229.61 \qquad SX\ SY = 155{,}786.48$

$$r_{XY} = \frac{NS(XY) - SX.SY}{\sqrt{[NS(X)^2 - (SX)^2]\ [NS(Y)^2 - (SY)^2]}}$$

$$= \frac{18 \times 7047.49 - 155{,}786.48}{\sqrt{(18 \times 2{,}426.79 - 36{,}983.14)\ (18 \times 51{,}076.75 - 656{,}229.61)}}$$

$$= - \ 0.689$$

$$t = \frac{r\sqrt{N-2}}{\sqrt{1 - r^2}} = \frac{0.69\sqrt{16}}{1 - 0.476}$$

$$= 5.26$$

$P = 0.001$

Conclusion—

There is a highly significant negative correlation between yield of cocoa pods and the rainfall during the fourth previous month.

RELATIONSHIP BETWEEN YIELD OF CACAO PODS AND RAINFALL FOR THE FIFTH PREVIOUS MONTH.

Month	Rainfall X	X^2	Month	Yield Y	Y^2	XY
Dec., ... '50	18.30	334.89	May, ... '51	40.9	1,672.81	748.47
Jan., ... '51	5.90	34.81	June, ... '51	107.0	11,449.00	631.30
Feb., ... '51	5.66	32.04	July, ... '51	84.4	7,123.36	477.70
Mar., ... '51	22.40	501.76	Aug., ... '51	10.7	114.49	239.68
Apr., ... '51	11.40	125.44	Sept., ... '51	0.08	0.01	0.09
May, ... '51	4.53	20.52	Oct., ... '51	62.3	3,881.29	282.22
June, ... '51	6.13	37.58	Nov., ... '51	99.8	9,960.04	611.77
July, ... '51	8.23	67.73	Dec., ... '51	54.0	2,916.00	444.42
Aug., ... '51	9.49	90.06	Jan., ... '52	32.4	1,049.76	307.48
Sept., ... '51	16.50	272.25	Feb., ... '52	17.7	313.29	292.05
Oct., ... '51	11.30	127.69	Mar., ... '52	31.6	998.56	357.08
Nov., ... '51	12.90	166.41	Apr., ... '52	23.2	538.24	299.28
Dec., ... '51	6.58	43.30	May, ... '52	44.0	1,936.00	289.52
Jan., ... '52	10.90	118.81	June, ... '52	34.8	1,211.04	379.32
Feb., ... '52	12.50	156.25	July, ... '52	25.9	670.81	323.75
Mar., ... '52	9.55	91.20	Aug., ... '52	42.0	1,764.00	401.10
Apr., ... '52	9.34	87.24	Sept., ... '52	66.2	4,384.44	618.31
	181.41	2307.98		766.98	49,981.14	6.703.54

$$^{r}XY = \frac{NX(XY) - SX.SY}{\sqrt{[NS(X)^2 - (SX)^2]\ [NS(Y)^2 - (SY)^2]}}$$

$$= \frac{17 \times 6{,}703.54 - 140{,}951.94}{\sqrt{(17 \times 2{,}307.98 - 32{,}909.59)\ (17 \times 49{,}981.14 - 603{,}697.92)}}$$

$$= -\ 0.79$$

$$t = \frac{r\sqrt{N-2}}{\sqrt{1-r^2}} = \frac{0.97 \times 3.87}{\sqrt{1 - 0.6241}}$$

$$= 5.16$$

N = 17 P = .001

Conclusion—

There is a very highly significant negative correlation between cocoa yields and rainfall for fifth previous month.

RELATIONSHIP BETWEEN YIELD OF CACAO PODS AND RAINFALL FOR THE SIXTH PREVIOUS MONTH.

Month	Rainfall X	X^2	Month	Yield Y	Y^2	XY
Dec., ... '50	18.30	334.89	June, ... '51	107.0	11,449.00	1,958.1
Jan., ... '51	5.90	34.81	July, ... '51	84.0	7,123.36	495.6
Feb., ... '51	5.66	32.04	Aug., ... '51	10.7	114.49	60.566
Mar., ... '51	22.40	501.76	Sept., ... '51	0.08	0.01	1.792
Apr., ... '51	11.20	125.44	Oct., ... '51	62.3	3,881.29	697.760
May, ... '51	4.53	20.52	Nov., ... '51	99.8	9,960.04	452.094
June, ... '51	6.13	37.58	Dec., ... '51	54.0	2,916.00	331.020
July, ... '51	8.23	67.73	Jan., ... '52	32.4	1,049.76	266.652
Aug., ... '51	9.49	90.06	Feb., ... '52	17.7	313.29	167.973
Sept., ... '51	16.50	272.05	Mar., ... '52	31.6	998.56	521.400
Oct., ... '51	11.30	127.69	Apr., ... '52	23.2	538.24	262.160
Nov., ... '51	12.90	166.41	May, ... '52	44.0	1,936.00	567.600
Dec., ... '51	6.58	43.30	June, ... '52	34.8	1,211.04	228.984
Jan., ... '52	10.90	118.81	July, ... '52	25.9	670.81	282.310
Feb., ... '52	12.50	156.25	Aug., ... '52	42.0	1,764.00	525.000
Mar., ... '52	9.55	91.20	Sept., ... '52	66.2	4,382.44	632.210
	SX = 172.07	$S(X)^2$ = 2,220.54		SY = 735.68	$S(Y)^2$ = 48,308.33	S(XY) = 7,451.22

$(SX)^2 = 29{,}608.08 \qquad (SY)^2 = 541{,}225.06 \qquad SX\ SY = 126{,}588.46$

$$r_{XY} = \frac{NS(XY) - SX.SY}{\sqrt{[NS(X)^2 - (SX)^2]\ [NS(Y)^2 - (SY)^2]}}$$

$$= \frac{16 \times 7{,}451.22 - 126{,}588.46}{\sqrt{(16 \times 2{,}220.54 - 29{,}608.08)\ (16 \times 48{,}308.33 - 541{,}225.06)}}$$

$$= -\ 0.19$$

Conclusion—

The negative correlation is clearly not significant.

KENAF OBSERVATIONS 1951-1952 AT THE LOWLANDS AGRICULTURAL EXPERIMENT STATION, EPO.

By T. Sorensen, B.Sc. (Agr.).*

IN view of the Territory wide interest in Kenaf (*Hibiscus cannabinus*) as a fibre crop, a small trial was carried out in the 1951-1952 season at the Lowlands Agricultural Experiment Station, Epo. The aim of the trial was to gather as much information as could be obtained from the limited resources, on the basic cultural requirements of Kenaf as a crop in this district. The following is an account of the trial and its results :—

An experiment of this nature must of necessity be carried out over several seasons in order to properly assess the relative importance of the various agronomic practices under consideration and their effect on economic Kenaf production. These results cover a period of one season only, and can only be regarded as an initial survey.

From a perusal of the available literature, it would appear that throughout the world there is considerable difference of opinion as to the most favourable sowing rates and planting distances of Kenaf as an economic crop. Watkins (12) in his observations in El Salvadore concluded that a spacing of 12 inches x 12 inches (54 plants/square yard) was the best of all those tried, and his results are approximated by those of David (7) who recommends that 50 plants/ square metre is the best sowing rate for conditions in the Philippines. Crane (2) makes the recommendation of a sowing rate of 25 to 30 lb. per acre in 12 inch rows for Cuba, and Crane et al (6) also for Cuba recommends 30 to 35 lb. per acre but in eight inch rows. Walker and Sierra (11) found that the fibre yield increases as the widths between the rows are lowered from 16 inch through 8 inch to 4 inch. They further state that extre row spacings of 5 to 10 plants per row foot brought about no differences to the productivity of the crop. From this evidence it would appear that the factor of plant density is more important than absolute and definite inter and intra-row spacings.

An attempt was made here to evaluate the agronomic effects of the spacing factor under Epo conditions.

Method.—

The size and scope of this trial was severely limited by the amount of seed available. As seed was in poor supply the experimental design as planned was that of a randomized block containing six treatments and four replications, but with the plots arranged in such a manner so that the experiment could be converted into a split plot design, should a further supply of seed be procured, with the date of planting as the major treatment. A further seed supply was later obtained and a second plot sowing made, but this was carried out far too late in the season, and at a time when the photoperiod requirements of an economic crop could not be met. Thus the results, though presented, have little practical interest.

The first planting was made over the period 22nd to 27th November, 1951, and the second, carried out only for seed, from the 15th to 26th February, 1952. Each of these plantings covered 24 plots of 1/40th acre area covering six spacing treatments with four replications. All plots were randomized. The spacing treatments were 7 in. x 2 in., 14 in x 2 in., 14 in. x 4 in., 21 in. x 2 in., 21 in. x 4 in. and 28 in. x 8 in. respectively. As the seed viability was first ascertained to be only 41 per cent., 4 to 5 seeds were planted per hole and the excess plants thinned out when their height was 6 to 8 inches.

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However, although the sowings were first commenced following a heavy fall of rain, no further rain was recorded for a period of six weeks and the germination was affected. The final germination obtained was only of the order of 11-12 per cent., which produced a great number of gaps in the stand for which no further seed was available for replanting. The intended spacings could not be achieved, and the analysis and interpretations of the results, recourse is had to the average density of plants per square yard of the plots as the criterion for comparison. The second planting made with newer seed and under more favourable conditions for germination, gave a germination percentage of 86 per cent., and this difficulty was not encountered.

The land selected for the trial had only one crop of rice grown on it in the previous season, before which it was virgin country. It was given a preparation consisting of two deep ploughings to 9 inches and two horrowings with a tandem disc machine prior to sowing in the case of the November sowing, and a further two harrowings to keep down weeds in the case of the February sowing. Planting was carried out by hand, and at the same time the few small weeds on the plots were likewise removed. No subsequent treatment was given to the crop until the time to harvest.

In the case of the crop of the first planting date, the plots at maturity were divided into two, one-half being harvested for fibre production, and the other half left for later seed production. The February planting, however, was harvested for seed only, the Experimental Station at that time requiring all the seed it could produce.

No fertilizer treatment was given to the plots.

Results.—

The November planting was commenced following a heavy fall of rain, but no further precipitation occurred for the following six weeks and the rapid drying of the land hindered germination. The surface soil became completely dry and these unfavourable climatic conditions early in the life of the crop are shown clearly in the growth figures. For instance, the average height in the plots of the 7 inch row spacing was only 18 inches at 30 days of age, 46 inches at 50 days, 69 inches at 65 days and the plots finally reached a maximum height of 93 inches. A slight wilting of the plant apices was noticed on the many hot and clear days. The February sown plots gave very satisfactory germination within three days from sowing and the crop, with the exception of the photoperiod, had ideal weather conditions for growth right thoroughout its life. In spite of the denser stand, which should have favoured taller growth, these plots only reached a maximum height of 68 inches, which is highly unsatisfactory, and which is considered a result of the unfavourable photoperiod.

Both crops experienced waterlogged conditions for periods of up to three weeks, without showing any noticeable effect.

TABLE 1

SUMMARY OF RESULTS : PLOTS OF THE NOVEMBER PLANTING.

Block	Treatment	Inter-row spacing inches	Average intra-row spacing inches	Average plant height at 50 days inches	Average plant height at maturity inches	Density plants/ sq. yard	No. of plants in plot	No. of plants branching	No. of plants borer attacked	No. of plants branching naturally	Total percentage branching	Total percentage borer attacked	Adjusted percentage natural branching	Seed Yield ozs/plot	Yield green weight lbs/ 1/80 acre	Percentage fibre recovery	Yield of fibre tons/acre
1	J	28	18.64	12	75	2.55	309	66	42	24	21.36	13.59	11.03	8	495	3.54	0.62
4	J	28	10.72	15	75	4.45	539	193	113	80	35.75	20.67	31.67	5	388	4.37	0.61
2	J	28	10	19	75	4.74	573	237	162	75	40.01	28.27	34.29	7	409	5.21	0.76
3	I	21	12.47	22	75	5.03	608	208	156	52	34.21	25.66	17.68	31	449	3.75	0.60
2	F	21	12.63	26	75	5.03	608	248	160	88	40.8	26.32	37.63	64	446	6.25	1.59
3	J	28	9.41	15	75	5.05	612	168	99	69	27.45	14.54	22.43	28	492	4.17	0.73
2	I	21	12.47	24	75	5.09	616	284	236	48	46.1	38.31	26.18	7	591	4.58	0.97
4	F	21	13.06	19	75	5.26	636	256	168	88	40.25	26.26	37.07	12	475	2.29	0.04
3	F	21	10.11	28	75	6.28	760	208	100	108	27.37	13.16	28.42	43	553	2.50	0.49
1	F	21	11.25	18	81	5.65	684	104	64	40	15.2	9.36	9.59	12	513	5.42	0.99
1	G	14	16	24	84	5.95	720	138	66	72	19.17	9.3	16.60	15	521	5.00	0.93
1	I	21	11.78	18	78	6.21	75.2	172	88	84	22.87	11.57	21.00	4	490	6.04	1.06
2	G	14	11.16	26	81	8.53	1032	222	150	72	21.51	14.54	17.44	20	573	3.33	0.68
4	I	21	8.07	16	75	6.48	784	256	180	76	32.65	22.96	27.14	19	530	6.25	1.18
4	G	14	6	28	81	11.80	1428	240	174	66	16.81	12.18	12.66	15	533	5.21	0.99
3	G	14	5.3	38	78	15.87	1920	132	78	54	6.88	4.06	5.01	44	491	5.00	0.88
1	H	14	9.8	28	84	17.20	2081	339	201	138	16.29	9.61	19.96	13	563	6.63	1.13
2	H	14	4.42	17	81	21.55	2608	456	344	112	17.48	13.19	18.99	6	746	4.58	1.22
4	H	14	4.01	27	78	23.75	2874	522	414	108	18.16	14.40	19.31	6	649	6.04	1.40
3	H	14	3.29	36	78	28.96	3504	246	150	96	7.04	4.25	6.85	15	581	6.88	1.43
4	E	7	5.12	32	81	36.41	4406	517	352	165	11.28	7.99	16.92	21	603	7.08	1.53
3	E	7	5.26	42	74	40.40	4889	364	270	94	7.45	5.25	7.03	42	682	6.88	1.68
2	E	7	4.26	35	90	43.80	5299	670	400	270	12.63	7.55	21.70	24	635	11.26	2.53
1	E	7	3.94	46	93	47.26	5718	94	82	12	1.64	1.43	0.38	10	635	6.46	1.46

SUMMARY OF RESULTS : PLOTS OF THE FEBRUARY PLANTING.

TABLE 2

Block	Treatment	Row spacing	Average number plants per row	Average spacing plants in row	Average height plants at maturity	Density (plants sq. yard)	Number plants in plot	Number plants branching	Number plants borer attacked	Number plants branching naturally	Yield Seed ozs. 1/40th acre
1	G	14 in.	291	1.64 in.	61 in.	57.72	6984	840	672	168	11
2	G	14 in.	450	1.06 in.	55 in.	89.25	10800	240	72	168	23
3	G	14 in.	492.7	0.97 in.	53 in.	97.7	118.24	288	72	216	22
4	G	14 in.	450	1.06 in.	48 in.	89.25	10800	192	96	96	24
1	E	7 in.	308.37	1.55 in.	59 in.	119.8	14491	1175	799	376	13
2	E	7 in.	427.6	1.12 in.	58 in.	166.2	20100	188	94	94	21
3	E	7 in.	446.7	1.07 in.	54 in.	173.5	20993	282	94	188	16
4	E	7 in.	347	1.38 in.	54 in.	134.8	16309	282	94	188	15
1	F	21 in.	430.62	1.11 in.	59 in.	56.94	6890	288	192	96	9
2	F	21 in.	526.6	0.91 in.	60 in.	69.63	8426	336	80	256	32
3	F	21 in.	423.6.	0.91 in.	61. in.	69.23	8378	128	32	96	16
4	F	21 in.	482.3	0.99 in.	58 in.	63.78	7717	80	48	32	8
1	J	28 in.	691	0.69 in.	62 in.	68.53	8292	552	228	324	11
2	J	28 in.	426.7	0.98 in.	54 in.	48.26	5840	396	108	288	35
3	J	28 in.	518	0.92 in.	56 in.	51.37	6216	156	24	132	22
4	J	28 in.	468.7	1.02 in.	60 in.	46.47	5624	48	24	24	11
1	H	14 in.	625	0.76 in.	56 in.	118.3	14375	782	322	460	20
2	H	14 in.	342	1.40 in.	57 in.	67.82	8208	552	120	432	49
3	H	14 in.	375.7	1.27 in.	56 in.	74.50	9016	168	48	120	5
4	H	14 in.	545.7	0.87 in.	63 in.	108.1	13096	168	96	72	32
1	I	21 in.	546.3	0.87 in.	54 in.	108.3	13112	1296	96	1200	15
2	I	21 in.	388.6	1.23 in.	55 in.	51.4	6218	432	64	368	29
3	I	21 in.	492	0.97 in.	49 in.	65.06	7872	64	48	16	5
4	I	21 in.	541	0.88 in.	56 in.	71.53	8656	176	112	64	21

A. YIELD OF SEED IN RELATION TO TIME OF PLANTING

The total yield of seed from all plots of the first, or late November plantings, was 470 ounces from three-tenths of an acre, whereas the seed yield from all plots of the second, or late February planting was 465 ounces, but from six-tenths of an acre. (In the November planting one-half of each plot was harvested for fibre.) Thus it can be clearly seen that the seed yield from the first planting was approximately double that obtained from the second, in spite of the fact that a much better and much more uniform stand of plants was obtained from the plots of the latter. The superiority in this regard of the November planting is outstanding so much so in fact that an analysis of this aspect of the experiment was not considered necessary.

The evenness of seed maturity did not seem to be effected by the planting dates, and both groups of plots matured their capsules over a period of approximately two months. The capsules clung well to the plant and did not shatter, even when lashed by heavy rains, but they suffered considerable damage from the depredations of the cotton staining insects, which were extremely numerous.

The plots of the first planting were harvested for seed as soon as all capsules were dry, and harvesting commenced on the 17th June, 1952, or 200 days after the completion of germination. The plots of the second planting were ready for seed harvesting on the 30th July, 1952, or 152 days after completion of germination, but they were not harvested until a fortnight later. Thus the effect of the photoperiod was clearly apparent, the difference in maturity being approximately 50 days.

The total seed yield was extremely poor and averaged only 83.6 lb./acre. The first planting averaged 97.9 lb./acre, over all the plots, and the second planting only 48.5 lb./acre. This is very unsatisfactory and in the case of some of the plots in the second planting was even less than the amount sown. The failure of the crop to yield seed is a serious drawback to a possible kenaf industry in this area and unless a much greater yield can somehow be obtained the possibility of commercial production will be hindered somewhat by the cost of seed importation.

The harvesting for seed was carried out by hand cutting the stems of the Kenaf at ground level and feeding them into a hand-driven Lewis Grant Rice Thresher, the operation being similar to that in the heckling of broom millet. This was followed by winnowing. The operation was satisfactory, but labour consuming.

B. YIELD OF SEED IN RELATION TO PLANT DENSITY.

The results of the two planting dates will be discussed separately as the respective plant densities do not allow for comparison.

1. *Late November Planting.*—

The results of the individual plots are set out in Table 3. As half of each of these plots were harvested for fibre the figures are expressed in ounces per one-eightieth of an acre.

TABLE 3

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total	Mean
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.37	5.70		
1		15	10	12	8	13	4	62	10.33
2		20	24	64	7	6	7	128	21.33
3		44	42	43	28	15	31	203	33.83
4		15	21	12	5	6	19	78	13
Total		94	97	131	48	40	61	471	
Mean		23.5	24.25	32.75	12	10	15.25		19.625

Table 4 is the summary of the statistical analysis of Table 3.

TABLE 4

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatments	1515	5	303	2.37
Blocks	2010	3	670	5.22
Error	1927	15	128.5	....
Total	5452	23	....	....

Thus the differences between the blocks is critical and approaches the 0.1 per cent. level, whereas the differences due to the treatment just fails to reach significance. It must be supposed that the treatment effect is masked by that of the block, and this will be discussed more fully later. Although the Kenaf crop is usually affected by soil variability, by far the most important factor producing this variation between the blocks is that of insect attack, especially attack by the *Earies* tip borer.

When the yield of seed per plot is arranged in accordance with plant density (as on Table 1) and then grouped into the respective categories, the following is the result :—

When plant density is 1 to 10, mean seed yield = 39.29 ounces.
When plant density is 10 to 20, mean seed yield = 46 ounces.
When plant density is 20 to 30, mean seed yield = 16 ounces.

When plant density is 30 to 40, mean seed yield = 43 ounces.

When plant density is 40 to 50, mean seed yield = 50.67 ounces.

This gives a correlation co-efficient of 0.640 which though not of very high order, points out the fact that within the limits of the experiment, there is a small rise in the yield of seed with an increasing plant density. This supports the results of the analysis of variance (Table 5) where the treatment differences just failed to reach the level of significance. With a much greater increase in plant density the yield of seed would presumably fall again, but the plant densities just discussed did not reach the critical point.

2. *Late February Planting.*

The results of the individual plots are set out in Table 5. The yield figures are expressed in ounces per plot of one-fortieth of an acre.

TABLE 5

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	1.18″	1.38″	0.98″	0.90″	1.08″	0.99″	Total	Mean
Block	Mean Plant Density	83.47	148.6	64.91	53.69	92.28	78.21		
1		11	13	9	11	20	15	79	13.17
2		23	21	32	35	49	29	189	31.5
3		22	16	16	22	5	5	86	14.33
4		24	15	8	11	32	21	111	18.5
Total		80	65	65	79	106	70	465	
Mean		20	16.25	16.25	19.75	26.5	17.5		19.38

Table 6 is the summary of the statistical analysis of Table 5.

Table 6. ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatment	297.4	5	59.48	....
Blocks	1270.5	3	423.5	6.5
Error	981.7	15	65.44	...
Total	2549.6	23	....	....

Thus there are no significant differences between the treatments of the second planting, but the differences due to blocks are highly significant. It is

assumed that the former is due mainly to the lateness of the planting, whereas the latter results from soil and insect damage variability.

C. YIELD OF FIBRE IN RELATION TO PLANT DENSITY.

Only the plots of the first planting were harvested for fibre, as the plots of the second plantings were required for seed. The first flowers were noticed on these plots on the outside rows on the 28th February, 1952, or 96 days after the first of the germination. Twenty days later the plots planted in 28 inch rows were flowering uniformly, and inside rows in the others were only just starting to come in. By the 23rd March the plots were ready to be harvested for fibre, 116 days after completion of the germination. It is quite apparent from the observations that maturity can be considerably hastened by increasing the available light to the plants by wider spacings and less plant densities.

Harvesting was carried out on the 24th March, the plants being slashed by hand at ground level.

The following table gives the yield of green weight and the figures are expressed in pounds per plot of one-eightieth of an acre. The weights were taken with the plants in a badly wilted condition.

TABLE 7

TREATMENT.

		G	E	F	J	H	I	
	Inter-row spacing	14″	7″	21″	28″	14″	21″	
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.87	5.70	
1		521	635	513	495	563	490	
2		573	635	446	409	746	591	
3		491	682	553	492	581	449	
4		533	603	475	388	649	530	
Total								13.043

This gives an overall average production of wilted green matter of 53,476.80 lb. per acre.

From the visual inspection of the stems at the time of harvest, it would appear that the plots of greater plant density produced the better fibre yield. With these the stems are straighter and finer and with a much lesser degree of branching. At the harvest all plots were showing slight to moderate lodging, with the lesser densities less affected than the others.

Thirty pounds of stalks of each plot were selected at random and subjected to tank retting individually in drums. The yield of pure fibre obtained is as follows, and is expressed in ounces per plot sample. Sampling is not considered quite satisfactory but the entire produce from the plots could not be handled by the station's facilities.

TABLE 8

Yield of Fibre per 30lb. sample—

TREATMENT

Block	G	E	F	J	H	I
1	24	31	26	17	27	29
2	16	54	30	25	22	22
3	24	33	12	20	33	18
4	25	34	11	21	29	30

Retting was resorted to as no decorticator is present on this Station, but this method of fibre preparation was found to be far from satisfactory as the fibre produced, though apparently of good quality, was somewhat discoloured. A better sample was produced when only the stalk ribbons were retted, and an extremely good and very clean sample was produced by hand decortication. Retting in ground water was not found as satisfactory as tank retting, and dew retting was completely unsuitable. A point worth noting in tank retting is that the water should be changed at least twice during the process. Tank retting in this case required 29 days for completion, but a week less would be sufficient for plots of the closer spacing.

In order to compare the percentage recovery of fibre from the various plots the following table was prepared (Table 9). Figures are in percentages.

TABLE 9

Percentages Fibre Recovery—

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total	Mean
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.87	5.70		
1		5.00	6.46	5.42	3.54	5.63	6.04	32.09	
2		3.33	11.26	6.25	5.21	4.58	4.58	35.21	
3		5.00	6.88	2.50	4.17	6.88	3.75	29.18	
4		5.21	7.80	2.29	4.37	6.04	6.25	31.24	
Total		18.54	31.68	16.46	17.29	23.13	20.63	127.72	
Mean		4.635	7.92	4.115	4.323	5.783	5.155		5.32

The overall average recovery of fibre from whole wilted plants =5.32 per cent.

The following is the summary of the statistical analysis of the above.

TABLE 10

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatments	39.48	5	7.896	3.35
Blocks	2.91	3	0.97	....
Error	35.31	15	2.354	—
Total	77.70	23	...	...

Therefore there is a significant difference in the percentage recovery of fibre when the various spacing treatments given are compared. The variation between the block is so minute that it can be completely ignored, which proves the effectiveness of the method of tank retting.

The critical difference in the percentage recovery between the various treatments is evaluated to be 9.25.

Thus it can be seen from the above that in the factor of percentage fibre recovery from retting, plots of an average density of 41.97 give a far superior yield to the others, whose differences amongst themselves do not reach significance.

From the figures listed on Table 1, it is obvious that percentage fibre recovery increases slightly with increasing plant density within the limits of this experiment, and under these experimental conditions of relatively poor plant stand and high insect attack. The high order correlation co-efficient is 0.8143.

The fibre yield for the plots was calculated and the figures presented in Table 11 for analysis.

TABLE 11

YIELD FIBRE.

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total	Mean
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.87	5.70		
1		0.93	1.46	0.99	0.62	1.13	1.06	6.19	
2		0.68	2.53	1.59	0.76	1.22	0.97	7.75	
3		0.99	1.68	0.49	0.73	1.43	0.60	5.75	
4		3.48	7.20	0.04	0.61	1.40	1.18	25.50	
Total		0.87	1.80	3.11	2.73	5.18	3.81	5.81	
Mean		1.53	0.88	0.7875	0.68	1.295	0.9525		1.0625

The following Table 12 is the summary of the statistical analysis of the above.

TABLE 12

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatment	3.50	5	0.70	4.9
Block	0.44	3	0.137	....
Error	2.15	15	0.143	....
Total	6.09	23	...	...

Thus there is a highly significant difference in the effect of the various treatments on yield of fibre, and the critical difference between the various treatments is 2.28 with the densely spaced group of plots significantly out-yielding all the others with the exception of the group immediately below it.

D. FIBRE YIELD IN RELATION TO PLANT DENSITY.

From the information listed on Table 1 it was calculated that fibre yield and plant density have a high order positive correlation of 0.842.

The chief notable drawback of this experiment was that the density range did not reach a sufficient magnitude.

The average yield of fibre per acre was only 1.06 tons, and the maximum yield recorded was 2.53 tons. This compares with the world average.

E. HEIGHT OF THE CROP IN RELATIONSHIP TO THE PLANT DENSITY.

From the figures given in Table 1 for the November planting, it is quite apparent that increased plant height results from increased plant density in accordance with the theory. In the first planting the 7 inch row spacings gave

FIBRE CROP OF KENAF READY TO HARVEST AT LALOKI NEAR PORT MORESBY.

the longest length of stem, followed by the 14 inch row spacings and the denser of the 21 inch spacings. The less dense 21 inch and 28 inch gave the least. Even so, the plant height in all cases was somewhat disappointing, and the tallest block gave only a final 93 inches.

With the second planting the differences in plant height were not apparent. This may have been due to the time of planting, but the greater density and uniformity of the plots is probably a contributing factor. Here the tallest plot gave only an average height of 63 inches.

F. NATURAL BRANCHING IN RELATION TO PLANT DENSITY.

From the figures in Table 1, the two factors of percentage natural branching and plant density were found to have a correlation co-efficient of 0.7571. This correlation is not as high as should be expected and which past work in other countries with similar crops would indicate. It is considered that factors other than that of plant density are also influencing the degree of natural branching in these plots. One such would be the degree of insect attack, especially that of the tip borer, which, by stunting temporarily some of the plants in the block, would tend to increase branching in the unattacked adjoining plants.

The figures in Table 1 were taken on the 10th January, 1952, when the plants were 47 days of age. A further count was made on the 18th March, 1952, but the figures for this are practically meaningless as much of the evidence of borer attack had disappeared, the plant tissues having healed. Thus for these figures it cannot be stated with any certainty whether the branching occurred naturally or was caused by borer attack. The figures for the adjusted percentage of natural branching in Table 1 were obtained by calculating the proportion of plants which would have branched naturally, but which were first attacked by borer, and adding these to the direct count of those plants which did branch naturally.

A similar count was also made for the plots in the second planting and the figures are given in Table 2. However, these plots were very uniform and both borer attack and natural plant branching were negligible in comparison. Also because of the much increased densities of the plots in the second planting, the two groups of figures cannot be directly compared to evaluate differences in regard to this aspect.

There was no evidence of any bifurcation in any plot.

G. INSECT DAMAGE.

A total of 17 insect species were observed attacking these Kenaf crops and it is obvious that the plant is most attractive particularly to HEMIPTERA and COLEOPTERA.

The insects comprised species of LEPIDOPTERA, COLEOPTERA, HEMIPTERA and ORTHOPODA. With the exception of two, they were foliage feeders, but, although foliage attack was very noticeable, the plants did not seem to suffer to any great extent. There were two species of considerable economic importance, the first being the cotton staining bug. This insect seems to cause considerable damage to the seeds, as it punctures through the young developing capsule into the ovule and its attacks are followed by secondary fungal development on the capsule. Much of the lack of seed yield could be the result of such depredations, and a trial to see whether this is so should be carried out.

The other serious insect pest, and which has been given great attention in these trials is the *Earias* tip borer. It attacked the plants in all stages of growth and bores down the tip of the stem completely destroying the terminal buds. This causes the plants to branch profusely, seriously diminishing the plant height

STANDING KENAF PLANT SHOWING DAMAGE BY BORER. (Note multiple branching.)

and the yield and the quality of fibre. Damage was particularly profound when the plants were attacked while still young. Depredations were very severe for the plots of the first planting but were insignificant on those of the second planting where the pest was of no longer of economic importance. However, as the second planting date has obviously an unsuitable photoperiod for the crop, and as the plots of the attacked planting far outyielded those of the other in both seed and fibre production, there can be no benefit in arranging the date of sowing to avoid attack by this pest.

The decline in attack could be attributed to parasites, which were probably helped by the drier weather. A chalcid wasp was bred out from attacked caterpillars.

H. INFLUENCE OF PLANT DENSITY ON BORER DAMAGE.

From the figures listed in Table 1, it can be calculated, that the factors of plant density and percentage plant attack by borers are correlated with a positive co-efficient of 0.7444.

The regression of the percentage borer attack on plant density is analysed in Table 13.

TABLE 13.

Factor	Sum of Squares	Degrees of Freedom.	Variance	F.
Regression	1063	1	1063	27.32
Error	856	22	38.9	....
Total	1919	23	....	....

Thus it can be readily seen that regression is highly significant, and that the percentage attack by borer in the plot falls considerably as the plant density increases.

J. INFLUENCE OF BORER DAMAGE ON YIELDS OF FIBRE AND SEED.

From the tabulated figures it can be seen that by far the greatest influence on yield of fibre from these Kenaf stands of the first planting is the factor of plant density. In its turn, the borer damage is also influenced considerably by plant density and there is obviously a multiple correlation between the three.

There appears to be no relationship whatsoever between percentage borer attack and yield of seed.

SUMMARY AND DISCUSSION.

1. An account is presented of a cultural trial with Kenaf carried out at the Lowlands Agricultural Experiment Station, Epo, Papua, in the 1951-1952 season.

2. The reported yields of fibre per acre are 1,000 to 3,000 lb. in Cuba (Crane[2]), 1,561 to 6,245 in India (Michotte), 3,300 to 6,600 in India (David[7]), 3.123 in Egypt, 1,296 in Rhodesia (Walters) and 3,103 lb./acre (Ergle[8]). The experiments of Crane and others (6) in Cuba gave a maximum yield of 5,569 lb./acre, whereas those of Walker and Sierra (11) gave a maximum of 3,603 and 3,296 lb./acre in 1946 and 1947 respectively. In the experiment presented here the maximum yield recorded was 5,667 lb./acre, and the average yield from the four plots with plant densities of between 40 and 50 plants/square yard was 4,032 lb. fibre per acre. Thus the yield of fibre compares very favourably to those of the recognized Kenaf producing countries. This is a somewhat remarkable conclusion when the factors of the unfavourable season for the first half of the crop growth, the great insect damage, the apparent lack of plant height, and the deficiency of density of the plants per square yard are considered. Although the results presented here are only those of a single season's investigations, it would seem that in spite of the obvious deterents to Kenaf growth which prevailed, the crop can be grown for fibre in this locality with yields highly favourable in comparison with those obtained elsewhere.

3. In regard to the influence of plant density on yield of fibre, the highest yield of fibre per acre was obtained from the four plots with an average plant density of 41.97 per square yard and this was the highest plant density of any group of plots which could be considered in this section of the experiment. On analysis the differences in yield of fibre from plot groups with a mean average density of 41.97, 22.87, 10.54, 5.70, 5.56 and 4.20, were highly significant, with the first far above the others, and the second only significant in comparison to the last. The critical difference was of the order of 0.57 tons/acre. A correlation of 0.842 was obtained between the factors of plant density and fibre yield. This experiment did not carry the plant densities to a level as high as their critical effect on fibre yield, but this is due to circumstances which have been previously enumerated.

4. A very interesting indication in this experiment was that the differences in the percentage fibre recovery of the plots were significant when the latter were grouped into their respective densities. The 41.97 density group gave a far higher percentage recovery (7.92 per cent.) than any of the others. The average percentage recovery was 5.32 per cent. from all plots. This former compares with the 5.5 per cent. recovery reported by Crane and Acuna (3) when it is considered that here the weight was taken with the plants in a wilted condition, whereas in the Cuba trials the plants were full and sappy and thus would not give as high a result. It is a well known fact that the percentage recovery varies with the age of the plant and Horst found that recovery was

1.66 and 2 per cent. at 97 days of age, and recovery then increased until it was 6.44 per cent. at maturity. Crane et al (6) found that recovery varied from 2 per cent at 40 days to 7 per cent. at maturity, but in this trial, the percentage recovery significantly increases with plant density, and has a positive correlation of the order of 0.8143. However, here there is a secondary factor of insect damage, which may have influenced the plots considerably in this regard as the plots of the higher plant densities were relatively less affected than those of the lower.

5. Although the second planting was not harvested for fibre, and although the plant densities obtained were much greater, there can be no doubt that the first planting would give a much higher fibre yield. It is considered that the photoperiod plays a major role and that a February planting is far too late for Kenaf in this area.

6. Both dew and tank retting were tried. Dew retting proved absolutely futile although what would appear to be favourable climatic conditions existed at the time. Tank retting proved highly effective, but the fibre produced was rather discoloured and possibly constant changing of water would tend to improve the produce. Retting in ground-water (up to 8 inches of muddy water lying in depressions) was not satisfactory. No decorticating machine is present in the area but hand decortication of a small sample gave excellent and clean fibre. Ribbon retting (outside strips of bark removed from the stems) was faster and superior to tank retting of the whole of the stem. Burkett et al (1) report that good quality produce can be obtained by tank retting, and Watkins and Allwood (13) report that tank retting gives good results when carried out at 34 degrees centigrade in a medium of pH between 6 and 8. It is concluded that retting should be a factor marked down for further investigation in this area.

7. Fibre quality could not be tested. However, during the rice harvest the station converted Kenaf by hand, and manufactured binder twine which proved highly satisfactory.

8. Plant density affects the time to blooming of the plants. It was found that the first flowers were produced in the first planting when the crop was 89 days old, but these flowers only appeared on the outside rows of the plot. The plots with densities of over 200 plants/square yard flowered much later than those of the lighter densities.

9. Photoperiod affected the time to maturity. In the November sowings the plots required 200 days to mature all capsules, and in the February sowings required only 152 days.

10. Total seed yield was very poor indeed, the average being only 83.6 lb./acre. The November plantings gave seed yields double those of the February plots. As harvesting the same crop of both seed and fibre has been found not to be feasible in both Cuba and El Salvadore (Crane and Acuna 4) it is possible that seed may not be produced in sufficiency and with economy to meet local demands for crops in this area, and that seed will probably have to be imported continually should Kenaf wish to be grown. This has been found to be the position also in other Kenaf countries and Narusevic (9) reports that Russian Kenaf seed is produced in Uzbekestan and the fibre crops in the North Caucusus.

11. Seed viability also was found to be extremely low. Immediately after the harvest the germination was only of the order of 2 per cent. Over a five month period viability gradually increased to 12 per cent.

12. The differences in the yield of seed just failed to reach the significant level in regard to plant density in the first planting. In the second planting there were no differences. Crane and Acuna (5) conclude that for Cuba spacing significantly effects yield of seed.

In this regard also the literature is at great variance. Dekker in Java reports that the best spacing for seed yield is 30 inches to 40 inches, Oliviera in Brazil considers 12 inches x 12 inches superior and Chousay in El Salvadore considers that 32 inches x 10 inches is the most satisfactory. On the other hand David in the Philippines considers that plant densities of between 15 and 50 per square metre are similar and Walker and Sierra state that a sowing rate of 20 lb./acre is the most satisfactory. For this area this factor as yet remains unknown.

13. Although in the February planting the plots are uniform in height, in the November planting the plots of the higher plant densities are far superior in height to the others. This has been observed elsewhere with Kenaf, by Crane and Acuna (4) and David (7) in Cuba and the Philippines respectively.

14. In the February planting the plots were more even and there was no effect of plant densities on plant branching. This is possibly due to the much greater plant densities obtained in these plots. In the November sowings branching decreased with plant density, giving a negative correlation of 0.8571. This is not as high as might be expected and possibly the factor of insect attack also plays a major role in this effect. Crane and Acuna (5) found, on the contrary, that spacing did not affect plant branching but the results presented here are supported by the findings of David (7).

15. Seventeen insect species were observed attacking these Kenaf crops and were sent to the Entomologist at Keravat for identification. Of these, only two are considered serious. The first of these is the Cotton stainer which seems to adversely affect seed formation and viability, and the second is the tip borer (*Earies sp.*) whose attack was investigated in these trials. This insect destroys the terminal bud and bores a short distance down the stem, forcing the plant to branch. If attacked very young the plant can be killed completely. The effect on the yield and quality of fibre would be considerable. The caterpillars are parasitized to a small extent.

It was found that an increase in plant density brought about a considerable decrease in percentage of plants attacked, and these factors have a negative correlation of 0.7444. The regression of attack on density is significant.

The attack in the second planting was very slight and unimportant, but the photoperiod is such that Kenaf must be grown when the attack is at its highest. It is thought that general sanitation measures should lessen the attack considerably. Insecticides were not tried as they were not available.

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A BRIEF HISTORY OF BOTANICAL EXPLORATION OF PAPUA AND NEW GUINEA

By J. S. Womersley, B.Sc.*

NEW GUINEA, one of the largest islands in the world is, together with Borneo, probably the least known country botanically. Situated as it is between Australia and the Philippines and between Indonesia and Polynesia, the flora shows distinct affinities with that of these neighbours. The study of such affinities and dissimilarity between the flora of different countries is known as phytogeography. Various authors have included New Guinea in the phytogeographic unit known as Malaysia. This unit includes Indonesia, Borneo, the Philippines and New Guinea, but not the Bismark Archipelago.

The study of the flora of Malaysia goes back to the dawn of history with the records of the Indian and Chinese authors of thirty centuries ago. These early references were essentially superficial and related almost entirely to religious or utilitarian values of the plants described. The Chinese seafaring traders from time immemorial carried cloves, areca nuts, sandal-wood and other vegetable products from Malaysia to China and in commenting on their discoveries composed the earliest descriptions but confined their writings primarily to the medical virtues of plants. The *Ayurvedas,* the most important Sanskrit botanico-medico work, is of uncertain age but contains 600 to 700 plant names.

The early Greeks brought the first factual information about Malaysian plants to Europe. The scientific advisers with Alexander's armies which penetrated the Punjab and Indus regions in 330 B.C. had a keen eye for botany. They came across the Banyan Fig Tree, *Ficus benghalensis* and by their notes enabled Theophrastus, who, incidentally is really the father of plant geography, to accurately describe the peculiar habits of these trees. They observed that from the horizontal branches aerial roots descend, enter the ground, thicken and take on the form of secondary trunks. It is interesting to note how these accurate early Greek writings have been overlooked and misunderstood by later authors. Meister, a European gardener who worked for several years in Java during the 17th century, wrote of a tree, the roots of which rise vertically from the ground till merging into branches. Among 18th century writers the same tale appears in a modified version when they describe downwardly growing branches which reach the ground and take root. A recently published American book by N. S. Knaggs caps all previous diversions from the truth with an account of the tree which sinks its branches into the soil, these emerge again to sink and emerge growing on each emergence into a full sized tree, so the tree marches through the forest.

This serves as an example of the errors of fanciful explorers and the merit of accurate data obtained by sober unbiased observers. It is not alone even among modern writings. Theophrastus also accurately described *Cycas* and the mangrove communities which, by their uniformity, are remarkable among the plant communities of the world.

For 1500 years from the time of the Greeks there was a particularly sterile period for phytogeography. Practically no botanical writings from this period have been discovered.

The voyages of the Portuguese, Spanish and Italian explorers into Asia during the middle of the 13th century, have left records of numerous botanical discoveries. The narrative of the travels of Marco Polo, published in 1296 mentions that he found rice growing in northern Sumatra. He has also mentioned in his notes

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Arenga, the sugar palm, *Cocos*, the coconut and *Dryobalanops aromatica*, a tree of the family *Dipterocarpaceae* which produces a valuable timber, a crystalline camphor and resin.

Various other travellers from the southern European countries wandered through India, Ceylon, Borneo and the nearby islands. About the beginning of the 16th century, the Portugese penetrated to the east while in Europe, but somewhat later, Brunfels and Fuchs set new standards for the illustration by painting of plants, Cordus for description by writing and Caesalpinus for critical taxonomy. With this development scientific botany was firmly established.

Not later than 1526 the Portugese reached the shores of New Guinea. From 1580, when Portugal came under the banner of Spain, the latter nation remained in power in Malaysia until the 17th century. Their botanical writings are, however, few and far between.

Early in the 17th century, the botanists in Europe were realising how rich was the flora of the east. Van Linschoten, the first of the Dutch to arrive at Goa, includes amongst his writings descriptions of the pineapple, jack fruit, mango, cashew nut, citrus, coconut, banana, etc. The spices and condiments were singled out for special treatment. 1600 saw the foundation of the Dutch East India Company. Variously referred to as a conspiracy of robbers and heartless oppressors, it is an historical fact that toward science the company behaved honourably, encouraging the collection of natural history specimens. It is interesting to read an instruction issued during this period to apothecaries and surgeons of the fleet. It is titled, " Recommendations for Apothecaries and Surgeons sailing on the Fleet in the year of 1602 for the East Indies." They shall bring back, laid between paper, branches carrying leaves and fruits and flowers, whenever possible, of nutmegs, both species male and species female, black pepper, white pepper, long pepper betle, cubebas, mangoes, mangosteens and similar beans of a kind of cotton growing in Bantam with branchlets and leaves and enquire after their local names. Similarly branchlets of all other kind of trees that seem strange and grow there with flowers, leaves and fruit, when possible the habit of the tree to be designed, whether they are large or small, whether they are green in winter or not. Their names in the vernacular, and to what end they are used.

You will notice that apart from the interests of commerce in the peppers, nutmegs and spices there was expressed the interests of science in calling for branchlets of all other kinds of trees. Apart from the collection of dried herbarium specimens the introduction of living plants into hot houses came into vogue. During the seventeenth century the botanists of the Netherlands came to possess the finest collections, both living and dried, of Malaysian plants in Europe. Their eminent position was achieved through the benevolence of the Dutch East India Company.

In 1753 all botanical work was revolutionized by the publication by Linnaeus of his Species Plantarum. In this now famous work Linnaeus proposed the binomial system of nomenclature which is now universally adopted in the biological sciences.

The pre-Linnaean period of Malaysian botany is one of superficiality until the Dutch, together with the Spanish and Portugese, revealed the east as a rich garden of plants. Linnaeus himself was little acquainted with the Malaysian species and, on the other hand, the botanists who were in close contact with the Malaysian flora had little contact with the Linnaean school. This combination of circumstances was unfortunate for subsequent Malaysian phytography. The Malaysian phytographers were under the impression that the species propounded by Linnaeus in the Species Plantarum included all the plants existing throughout the world. Consequently species completely unknown to Linnaeus were fitted in to sometimes not even closely related species described in the Species Plantarum.

A broadening of the species limits originally proposed by Linnaeus was the outcome. This has created many mis-interpretations of Malaysian species which were described during the latter part of the 18th century.

Linnaeus' work was most conducive to clearer phytography and constructive taxonomical research, but this new light focused on South Africa, Europe and America rather than Malaysia.

In the early part of the post-Linnaean period the tempo of exploration which started to rise during the period of Portugese domination in Malaysia, accelerated. The East India Companies of other nations followed the Dutch example by instructing captains and crews to bring back specimens of the natural flora of the islands visited.

Several English travellers followed Cook into the waters of Malaysia and Forrest explored parts of the Molluccas and New Guinea, searching for nutmeg seedlings.

Solander, travelling with Cook in the *Endeavour*, visited the south-west parts of New Guinea during 1770. The collections made by Solander, while few in number, are the first which may be reliably accepted as of New Guinea origin.

During the latter part of the 18th century, scientific journals, especially in England, became established. *Curtis Botanical Magazine* began publication in 1787. This journal continues to-day as a magnificent series of coloured plates and descriptions. Numerous Malaysian plants have been figured and described herein.

The *Annals of Botany*, the *Transactions of the Linnean Society* of London commenced publication about the same time. Both these journals have accommodated papers on Malaysian botany.

The explorations of the French in the East and Pacific brought to light little of botanical interest.

There is not space to pursue the history of the plant exploration in Malaysia as a whole from the end of the 18th century up to the present time. It will suffice to say that the Dutch have been quite the most outstanding as a nation in furthering the botanical knowledge of the East Indies.

I have already mentioned Solander's brief contact with New Guinea. This was followed in 1824 by a visit to Dorei on the Vogelkop Peninsula of the French ship *Coquille*. R. P. Lesson made quite large collections at Dorei while the *Coquille* was there. A year or so before the better known French botanist Gaudichaud collected on Rawak Island just off the coast of the Vogelkop Peninsula.

In 1828 Zipelius, a botanist to whom due recognition of his work has not been given, visited the south-west coast of what is now Dutch New Guinea. Considerable collections were made at Etna Bay and Triton Bay. Zipelius was more than a collector and his manuscript contained descriptions of many New Guinea plants. These were never published under his own name but it would seem that many of Blume's species should rightly have been credited to Zipelius.

After Zipelius there was another long gap in the botanical exploration of New Guinea. Teysmann in 1870 visited Dorei, where Lesson had collected on the Vogelkop Peninsula, d'Albertis and Beccari collected at Hatam also in the Vogelkop Peninsula and in 1875 Naumann visited the Territory of New Guinea in the German ship *Gazelle*. Naumann was fortunate that the *Gazelle*, which was on a voyage of discovery, called at several points on New Hanover, New Ireland and New Britain, also on Bougainville at Kaiserin Augusta Bay. Naumann's collections are the first of the prolific German herbaria which were to follow. In the same year, 1875, Sir William Macleay visited the islands of Torres Strait and the south coast of Papua, Macfarlane collected on the Fly River and d'Albertis visited Yule Island and Mekeo, after which he spent two years amassing a

considerable herbarium on the Fly River. d'Albertis travelled upstream some considerable distance. Sir William MacGregor, writing in the Annual Report of British New Guinea, 1889-90, states that the map of the Fly River as prepared by d'Albertis was tolerably accurate up to the junction of the Fly River with the Alice River, but beyond this point d'Albertis' map bore no resemblance to the actual course of the river. It was, therefore, impossible for him, *i.e.* MacGregor, to determine the furthest point reached by d'Albertis.

Most of the plants collected by d'Albertis were identified by Beccari, although Mueller, at the Melbourne herbarium, received at least some material. Beccari's *Malesia* deals with many of the d'Albertis plants.

In 1889 and 1890 Otto Warburg and Burke collected near Manoekwari and Hatam respectively in the Vogelkop Peninsula. Burke's collection consisted almost entirely of orchids.

In the Territory of New Guinea Hollrung was busy from 1886 to 1888 in the vicinity of Finschhafen. Karnbach also collected in this locality about the same time. Hellwig and Burke explored the Sattleberg and Cromwell Mountains making considerable plant collections during 1889.

Warburg also visited Finschhafen during 1889-1890 and collected in that locality. He also collected on New Britain (Blanche Bay) and on New Hanover.

During the period 1890-1900 the prolific collectors, Schelchter and Lauterbach, were at work. Carl Lauterbach during the ten year period collected in the vicinity of Finschhafen, the Sattelberg Mountains, the Huon Gulf, Salamaua, Astrolobe Bay, the Ramu Valley and adjacent mountains, the Bismark Mountains, Blanche Bay and coastal districts of the Gazelle Peninsula and Nusa Bay on New Ireland.

Schlechter came to New Guinea in search of trees producing a latex having the properties of guttapercha. He explored and collected widely in the vicinity of Finschhafen, the Ramu Valley, the Gazelle Peninsula and the Bismark Mountains. Schlechter has the distinction of describing more than 1,000 species of orchids in addition to numerous species of other families.

In 1912-1914 the Swiss botanist Ledermann made extensive collections in the Sepik River and nearby foothills and mountains.

The 1914-1918 war terminated the activities of the German botanists in the field. They pursued their herbarius work with vigour, publishing many papers on the botany of New Guinea.

Only sporadic collections were made in the Territory of New Guinea between the two world wars, the most important of which are those of Lane-Poole, who collected during an inspection of the forests of New Guinea. Father Peekel, in New Britain and New Ireland, made considerable collections which were sent to Berlin and Mrs. Clemens spent some time at Mission Stations in the Salawaket Mountains, Markham Valley and at Morobe. Most of the specimens were sent to Berlin or America.

In Papua there were a number of collectors, mostly missionaries, in the latter part of the 19th century. Chalmers and Goldie travelled widely in the coastal and near coastal districts. Their collections were sent to Baron von Mueller in Melbourne. Mueller published a series of papers on these specimens under the title of "Descriptive Notes on Papuan Plants." The material which Mueller had at his disposal was primarily coastal, so it is not surprising that only a relatively few new species were described by him, most of the plants collected being already known from the north Australian or Malayan coastal belts. He is none the less a noteworthy contribution to Papuasian phytography.

Forbes made quite a large collection in the region of Sogeri. Many new species have been based on his material.

Prior to his tour of New Guinea of which I have written, Lane-Poole made an inspecion of the Papuan forests and collected a series of specimens. Carr, a Malayan orchidologist, visited Papua in the early 1930's collecting for the British Museum. An incomplete set of his plants is now housed in the C.S.I.R.O. Division of Plant Industry Herbarium, Canberra. This set was originally the property of the Papuan Administration but, due to financial difficulties, was sold to the Commonwealth Forestry School at Canberra and from there was passed to the C.S.I.R.O. Herbarium. Only eight sets of his plants appear to be in existence.

Quite the most notable recent collections have been those made by L. J. Brass. Brass accompanied the expeditions organised by Richard Archbold. These were primarily ornithological expeditions but Brass was attached as botanist. The first of these was the 1933-34 expedition from Hall Sound to Mount Albert Edward. In 1936-37 the second expedition penetrated to the central range at the headwaters of the Fly River and also collected in the lowlands near the Wassi Kussa River. The party therefore covered a great deal of the ground which d'Albertis covered. Among the collections are many plants not recorded between the time of d'Albertis and the present day. The whole of the botanical material from these and the third Archbold Expedition, which will be discussed later, was sent to the Arnold Arboretum in America. The staff, led by Dr. Merrill and Miss Perry, have worked up the collections and distributed duplicates. A number of the duplicates have been donated in exchange to the Department of Forests Herbarium at Lae.

Numerous papers have been published in the *Journal of the Arnold Arboretum* on the plants from these collections. Merrill and Perry with the series *Plantae Archboldianae* and A. C. Smith with his series *Plantae Papuanae* have been the most prolific authors. Many new species have been described.

In Dutch New Guinea a number of small collections were made during the years following 1900. Kock collected on the south coast near Merauke, Versteeg on the southern side of Mount Wilhelmina, Branderhorst generally along the south coast from Merauke westwards. In 1911 Boden Kloss made some important collections when he ascended Mount Carstenz in the Nassau Range from the southern side. Boden Kloss was botanist with the British Ornithological expedition led by Wollaston. Entering New Guinea at the mouth of the Utakwa River the party crossed the coastal plain and the ranges immediately inland. A river valley was then followed leading to the permanent snow line on Mount Carstenz. The botanical collections of Kloss have been worked up by Ridley, whose published report under the title "Botanical Results of the Wollaston Expedition" appeared in the *Transactions of the Linnean Society of London*.

In the northern part of Dutch New Guinea there were a number of expeditions to the central range from the coast. Those of Doorman to the Doormantop and Lam in the same region are notable. The Vogelkop Peninsula continued to receive considerable attention from visitors entering through Manoekwari. Miss Gibbs collected much material in the Arfak Mountains. This was worked up by the collector and the results published in a book entitled *The Phytogeography of the Arfak Mountains*.

The third Archbold Expedition was made to Mount Wilhelmina from the northern coast. Again led by Richard Archbold, the expedition was formed with the co-operation of the Government of the Netherlands East Indies and styled "The Indisch-Amerikaansche Expeditie". A technical staff of six included an entomologist, 2 foresters, ornithologist, mammalologist and botanist. The flying boat *Guba* was used to establish a base on Lake Habbema from the coastal base at Hollandia. Lake Habbema, with its large water surface, provided a very satisfactory base close to the slopes of Mount Wilhelmina. The botanical collections comprised over 6,000 numbers with numerous duplicates. Most of the

collections were made between 3,500 feet and 10,000 feet, although a few specimens were collected from the summit of Mount Wilhelmina itself.

There have been many other small collections, some quite unrecorded, which have been made in various parts of New Guinea. I have, with these exceptions, considered the most important collections made up to 1940.

Published work on the phytogeography of New Guinea has appeared in numerous journals. The German authors published the *Flora of New Pommern, Flora von Kaiser Wilhelmsland, Flora Deutschen Schutzgebiete in der Sudsee* and the *Flora of Micronesia.* This latter work, which appeared in the *Botanische Jahrebucher*, does not embrace specimens actually collected in New Guinea, but many of the species which are described in the *Flora of Micronesia* undoubtedly do occur in New Guinea.

More recent German work has been the fine series of papers under the general heading *Flora Papuasien* in Engler's *Botanische Jahrebucher.* The series was under the general editorship of Lauterbach but is now entrusted to Deils. 150 parts were issued up to the outbreak of war. Papuasia, for the purpose of this study by the German botanists, has varied in extent from the former German Colony alone to the whole terrain from the Vogelkop Peninsula to the Solomons. Many families have been virtually monographed, others merit a very sketchy treatment.

The Dutch botanists at the Rijks Herbarium in Leiden and the Herbarium at Bogor (Buitenzorg) in Indonesia have published numerous papers on New Guinea botany, including some excellent monographs on families occurring in Malaysia.

The outstanding Dutch publication is without doubt *Nova Guinea.* This publication, which has appeared at irregular intervals, embraces volumes I-XVIII and volumes I-IV, the last appearing during 1940, of the New Series. *Nova Guinea* is sponsored by the Netherlands Government. The publication was intended to receive work of ethnography, geography, geology, botany and zoology of Dutch New Guinea. As a botanical publication, *Nova Guinea* is indispensable to any one working on the flora of New Guinea. With one exception, keys have not been included in this work. The *Flora Papuasien*, in contrast, is full of keys and consequently the more useful work. In the main the botanical papers included in *Nova Guinea* are an assemblage of descriptions of new species or notes on little-known ones.

Notable publications in English have been Ridley's papers on the Botany of the Wollaston Expedition to which I have already referred, Miss Gibbs' *Phytography of the Arfak Mountains* and further papers by Ridley on the Forbes collections from Sogeri.

Australian botanists have been rather overshadowed by their European colleagues. Mueller published his *Papuan Plants* during the years 1875 to 1890. This work was based on the collections of MacGregor, Chalmers, Goldie and other Missionaries. Bailey, then White and Francis, published a number of short papers in the *Queensland Agricultural Journal* and *The Proceedings of the Royal Society of Queensland.* Recently Blake and Smith, also working in Queensland have published papers on New Guinea plants.

Mr. C. T. White, until his death, Government Botanist in Queensland possessed an excellent working knowledge of the New Guinea Flora, having made several visits to the island. His most important papers relating to New Guinea botany are several in the *Journal of the Arnold Arboretum.*

During the years that White was Government Botanist in Brisbane, he built up the Herbarium of New Guinea plants to the stage where it is easily

the most representative in Australia, though perhaps the most poorly housed. Other valuable collections of New Guinea plants are in the National Herbarium of Victoria where the specimens handled by Mueller are kept and at the Herbarium of the C.S.I.R.O. Division of Plant Industry in Canberra. A set of the Carr collections are housed there.

American interest in New Guinea phytography was stimulated by the botanical collections of Archbold-Rand expeditions. Primarily ornithological these expeditions were first to Hall Sound and Mount Albert Edward, the second to the headwaters of the Fly and the third to Lake Habbema and Mount Wilhelmina in Dutch New Guinea. The entire botanical gatherings of these expeditions were entrusted to the Arnold Arboretum in America. Dr. E. Merrill and Lily M. Perry together with A. C. Smith have systematically worked through the collections and published a series of papers in the *Journal of the Arnold Arboretum* dealing with the collections.

The writings of Merill, Perry and A. C. Smith are quite the most valuable of the recent publications.

The recent war necessitated the production of considerable quantities of timber for local use within the Territory. Army Forestry companies provided this timber. Our present Director of Forests, Mr. J. B. McAdam was able to have Mr. Lindsay Smith from the staff of the Brisbane Herbarium attached to the companies as Botanist. Under Smith's direction about 2,000 numbers, each consisting of 8-10 duplicate sheets were collected of ligneous plants. Most of this material was sent to Brisbane for distribution but a nucleus has been left at Lae and provided the basis for our Herbarium when I took over in 1946. Smith has worked up certain families from these collections but the overall position regarding the systematic study of this material is not very satisfactory.

In Europe the war was responsible for the destruction of most of the collections kept in the Berlin Herbarium. The German botanists preferred to retain the whole of the collection from New Guinea under their immediate care so that practically no duplicates had been distributed. Innumerable type speciments have been lost and the only available information for now and all time for the species based on these type specimens will be the published descriptions. New Guinea botany will suffer for many years from the loss of the material in Berlin. It is fortunate that even a few of the Lauterbach duplicates have been located in Breslau, and a very few are interspersed in the Herbarium at Brisbane.

We are now in a position to consider the present position of systematic Botany in New Guinea.

Since 1948 a new publication *Flora Malesiana* has been produced on an international basis for the promotion of botanical science and the cultural advancement of the people of the South-Eastern Asia to South-West Pacific Region. This publication will ultimately cover the entire history of botany in the Malaysian region and systematically revise the plant families found therein. Much of the historical information used in this article is taken from *Flora Malesiana*, Series 1, Vol. 4, Part 2, *Short History of the Phytography of Malaysian Vascular Plants*, for which the author is indeed grateful.

Botanical work in Papua and New Guinea is centred on the Herbarium of the Department of Forests at Lae. The present collections exceed 5,000 sheets and are growing actively. With the appointment of Mr. A. Floyd as Ecologist—Assistant Botanist, it will be possible to accelerate the rate of collection and acquisition of material into the Herbarium. The Resource Survey Section in conjunction with Officers of the Papua and New Guinea Administration is adding considerably to our knowledge of the New Guinea Flora.

From time to time the Herbarium receives collections of plants for indentification from residents of the Territories. If these specimens are adequate they are incorporated in the Herbarium. Some hints to collectors of botanical materail are given in the adjoining article.* Specimens from residents throughout the Territories will always be welcome and the staff of the Herbarium will undertake their indentification as speedily as possible.

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* See *Notes on the Collection of Botanical Specimens,* Page 62 of this issue.

INVESTIGATION OF THE RUBBER INDUSTRY IN PAPUA AND NEW GUINEA—I

C. E. T. MANN,

(Director of the Rubber Research Institute of Malaya).

(Mr. Mann's detailed report on the rubber industry in the Territory is being published in two sections in this and the January, 1954, issues of the *Gazette*.)

Introduction.

In 1952 the author of this report was invited to visit the Territory of Papua and New Guinea to make observations and to report upon the rubber producing industry in these Territories. The terms of reference are quoted below.

Terms of Reference.

(A) To report on the quality of Papuan rubber and the efficiency of present methods used in the Papuan rubber industry judged by standards in other countries, and to suggest means of improvement in methods and product. This report should include comment on the following specific matter :—

(i) Location of existing plantations with respect to terrain, accessibility, climate, etc.;

(ii) Soils, soil deficiency and manuring;

(iii) provision of high yielding plant material including local selection of high yielding clones and cross-breeding;

(iv) Disease and pest control;

(v) Methods of cultivation, planting and harvesting (including mechanization);

(vi) Factory techniques;

(vii) Methods of preparation for market—

(*a*) baling;

(*b*) grading, particularly reclassification of grades and chemical grading;

(viii) Advisability of establishing a central (co-operative or other) factory; and

(ix) Desirability of concentrating on latex production and the problems involved.

(B) To advise upon setting up a rubber research scheme.

(C) On the assumption that some expansion of the industry is desirable, to advise upon best methods of achieving expansion.

(D) To report to the Department of Territories, Canberra, on the above matters.

Field observations were undertaken in August and September, 1952, these are reported in the following sections together with comments on the specific matters indicated in the terms of reference.

PART 1.

THE writer's experience in the rubber producing industry has been gained mainly in Malaya and is supplemented by some acquaintance with the industry in other territories, namely Ceylon, Indonesia, Thailand, Vietnam (Indo-China) and British Territories in North Borneo. In accordance with the first term of reference, which asks for comparison of the Papuan rubber industry with the industry in other countries, a brief outline of the development of the rubber

plantation industry in other countries is first presented. This outline is based largely on development in Malaya; where notable divergences in the course of development in other territories have occurred, reference is made to them.

From the introduction of the Para rubber tree (*Hevea brasiliensis*) to the Far East in 1876, first to Ceylon, and from Ceylon to Malaya and Indonesia and other countries, the gradual development of a rubber plantation industry has followed a very similar course in the principal producing territories. The common stimulus was of course the rise of the motor car industry and the need for rubber for pneumatic tyres, which still remains the largest single field of consumption of rubber. The first planting of Hevea rubber as an estate crop was made in Ceylon and Malaya in the last decade of the last century but large-scale development may be regarded as starting in the first decade of the present century; the industry is about fifty years old. The earliest plantings of Hevea in Papua and New Guinea are believed to have been made between 1901 and 1905.

The industry developed rapidly in Ceylon, Malaya and Indonesia: financed mainly by British and Dutch capital, it remained during the first decade of its development almost entirely a large plantation enterprize. The rapidly increasing demand for rubber resulting in the "boom" years of 1910 to 1914 stimulated further planting not only by large company organizations, but also by Native land owners in the principal producing countries. In Papua the industry has remained almost entirely a European enterprize.

Much has been written on the advantages and disadvantages of rubber as a permanent crop for Native cultivation; the objections to it, that have become increasingly evident in the past decade, might well have been avoided by wiser planning and control in the early stages of the development. It has been stated, for example, that unrestricted planting of rubber by Native land owners has prevented the development of a rational system of Native agriculture in which a proper balance is maintained between food production and the cultivation of cash crops. This is undobutedly true in many districts in Malaya and probably in other territories, on the other hand much Native planting of rubber has been done on land that is quite unsuitable for the continued cultivation of short term food crops although it can be productively used in the cultivation of a permanent crop that will thrive reasonably well on soils of only average fertility. In another connection the planting of a permanent crop, whether it be rubber or any other tree crop, provides a valuable means of checking the wasteful system of shifting cultivation practised by relatively primitive peoples. The establishment of a perennial cash crop may prove an essential first step in the development of a rational system of Native agriculture based on permanent settlements with a proper balance of short term food crop production, with livestock and permanent cash crops. No excuse is offered for this digression, for the development of a Native rubber growing industry in the wake of the advancing plantations has been a common feature of the development of the industry in Malaya, Ceylon, Indonesia and North Borneo. Exceptionally, rubber production in Sarawak and Thailand has been developed almost entirely by Native land owners, and company-owned estates represent only a very small proportion of the total rubber producing areas in these countries (see Table 1). On the other hand, practically the whole rubber producing area in Indo-China has been developed in Cambodia and Cochin China in large highly organized modern estates by a small number of companies with French capital; of the planted area of close on 330,000 acres only 6 per cent. represents Native planting whilst the labour employed to develop and operate the plantations has been recruited largely from Tonkin and from other provinces of the country.

Rubber is not a difficult crop to grow, it does not demand a fertile soil, neither is a high standard of skill required in its cultivation beyond reasonable care and attention during the first year or two from planting; these considerations favour its adoption by Native land owners. On the other hand, systematic

harvesting and preparation of the crop are laborious and skilled occupations, involving regular daily work; this makes the crop less attractive to more primitive people whose essential food production is not an arduous business and whose cash needs are small.

It will be noted that the establishment of the rubber plantation industry made rapid progress in Ceylon and Indonesia, where during the early years of its growth there was adequate local labour already skilled in tropical agriculture, in the production of copra, coffee, tea, sugar and other major crops. Similarly in Malaya, at least in the initial stages, there was an adequate supply of labour of the indigenous races, including immigrants from Indonesian territories, and immigrant Chinese agricultural labourers. As the pace of development increased there was no difficulty in attracting additional labour from other territories and immigration was encouraged.

Gradually the pattern of the industry in Malaya emerged. The estates opening from virgin forest land employed Chinese labour for the heavy work of felling, clearing and preparation for planting. Planting, cultivating and harvesting has been largely undertaken by immigrant South Indian labourers who have gradually become the permanently settled, specialist workers of the large plantation section of the industry. Meantime the Malay land owners, many of whom had worked on the plantations in the early days, cleared and planted their own land, often with the help of immigrant labour and with planting material readily obtained from the estates. Between the two extremes of the large Company enterprize of several thousand acres and the family smallholding of from two to five acres, plantations of all sizes have been established. The industry is now regarded as consisting of two main sections, the estates, of 100 acres or more, and the smallholdings, comprising properties of less than 100 acres. The average distribution between these two categories in the principal producing countries is shown in Table 1.

TABLE I.

World areas under Rubber, Estates and Smallholdings, in acres (a)

Territory	Estate	Smallholders	Total
Malaya	2,107,000	1,374,000	3,481,000
Indonesia	1,567,000	3,200,000	4,767,000
Ceylon	359,000	280,000	639,000
India	83,000	54,000	137,000
Burma	68,000	43,000	111,000
North Borneo	74,000	59,000	133,000
Sarawak	18,000	222,000	240,000
Thailand	19,000	400,000	419,000
Indo-China	311,000	20,000	331,000
Totals	4,606,000	5,652,000	10,258,000
(*b*) Papua and New Guinea	(*c*) 25,623	762	26,385

NOTES.—

(*a*) Data in this table are obtained principally from the official figures published by the International Rubber Regulation Committee in 1944 (*The History of Rubber Regulation 1934-43.* Edited by Sir Andrew McFadyean; Allen & Unwin, London), Minor corrections indicated by later information have been made.

(*b*) The data for Papua and New Guinea are from latest official records.

(*c*) Of the smallholdings not more than 300 acres represents Native owned plantings.

The pattern of development in Java and Sumatra has been similar to that in Malaya except that in Java with its dense population there was never any problem of shortage of labour for the new crop, in fact the development of the rubber plantation industry provided a welcome outlet for surplus labour from Java in the establishment of the large plantation industry in the East Coast district of Sumatra. Furthermore, the planting of rubber by smallholders in previously undeveloped areas of South and West Sumatra and in South Borneo was encouraged and fostered by the former Dutch administration with the result that the total acreage of rubber smallholdings in the Republic of Indonesia is estimated to be not less than 3,000,000 acres. Much of this planting has been carried out on land that might have reverted to secondary jungle, or possibly have become derelict, under the wasteful system of shifting cultivation which still obtains in the less advanced parts of Malayasian territories. In Ceylon, as in Malaya, South Indian immigrant labour was brought in to work on the large estates, whilst Ceylonese landowners established their own smallholdings. In North Borneo the pattern is much the same with 55 per cent. of the total acreage in large Company owned estates and 45 per cent. consisting of smallholdings. However, the smallholdings in North Borneo have been developed almost entirely by immigrant Chinese settlers the Native Malay races having shown little interest in rubber cultivation in the territory.

It will be clear from the foregoing, and a glance at the data in Table 1, that a close comparison of the development of the rubber industry in Papua and New Guinea with that in most other rubber producing territories is by no means straightforward. Possibly the nearest parallel would be with North Borneo where the estates have been developed by capitalist enterprise and now employ indigeous labour, but the comparison is only valid to a limited extent. In North Borneo the original opening and planting was mainly undertaken with immigrant Chinese and Javanese labourers, many of whom have long since settled, taken up land and gone into business on their own account, but for harvesting and general maintenance estates rely largely on indigenous Native labour, a large proportion of which is seasonal, working on the estates between the periods of rice planting and harvesting.

In the absence of a close parallel the most useful approach may be a comparison between a typical Malayan estate and one of comparable acreage in Papua. Taking for example an estate of 1,500 acres, the Malayan estate organization would be approximately as follows—

One European manager, exceptionally one junior European assistant manager, with a small office staff of one senior Asian clerk/book-keeper and possibly one junior assistant clerk. In the field, one Asian assistant or conductor to supervise tapping and general field work, with a junior conductor if there should be a large programme of replanting. In the factory, one Asian factory and store clerk, who is usually a qualified " dresser " or medical attendant, and may share part of the office work. A labour force of approximately 400 includes both male and female adult workers. This basic labour force, one adult labourer to four acres, lives on the estate, the estate providing approved housing accommodation, medical attention, a school, a Native temple, a day nursery for younger children and many other facilities as required by the Labour Ordinance. The estate also provides the same facilities for dependants of labourers, these may account to about 40 per cent. of the total adult labour forces; dependants and children are given casual work on the estate. Labourers are organized in small groups for their specific duties, tapping, weeding, disease control, etc., each group under the supervision of a foreman, an experienced worker and instructor, appointed by the manager. The estate also employs a small staff of locally trained artisans, carpenters, engine drivers and fitters adequate for the operation and routine maintenance of machinery and equipment; for major jobs skilled professional services are readily available. All

estate labourers are paid in cash, in accordance with standard rates agreed by negotiations between the estate workers' trade unions and the employers' associations. Estates may assist their labourers by purchasing food supplies, particularly rice, in bulk for distribution at cost but such arrangements have largely given place to the establishment of estate co-operative stores, managed by the labourers, or by estate shops operated by a Native shopkeeper under the nominal control of the management of the estate. The estate also provides land for labourers' gardens and a grazing area for cattle, with sheds and byres, this provision being especially important for Indian labourers who customarily invest a large part of their savings in livestock.

The organization briefly outlined above is typical of the older medium sized estates in Malaya. The resident labour force is usually of the Tamil race, originally recruited from South India and now more or less permanently settled on the estates. In many of the older planting districts on the coast a large proportion of the labourers may have been born and brought up on the estate and have in their various occupations attained a high level of skill in all branches of rubber cultivation and manufacture. In comparison with this organization the picture in Papua on an estate of comparable size exhibits many contrasting features.

In Papua mangerial supervision is provided on a basis of one European for about 500 acres. An estate of 1,500 acres in full production would probably employ one manager and three assistant managers. Experienced subordinate staff, equivalent to the Asian office, field and factory staff are usually of the same race as the labour force, as employed in Malaya, are not found in Papua. Thus a most important link between the administration and the labour force, as judged by accepted practice in Malaya and in most other major producing countries, is hardly represented in the Papuan plantation industry. It is not a simple matter to assess the true significance of this essential difference. In practice it means that in Papua all field and factory supervision and instructions of labour, together with essential clerical work, crop recording and costing of field work has to be done by the European staff. The employment of a limited number of " boss boys " some of whom are experienced helps to some extent in the training of raw recruits. A full labour force for an estate of 1,500 acres, on the basis of one man for 3 to 4 acres, would be 400 to 500 labourers. The present system of employment provides for the recruitment of men only, rarely are entire Native families employed on an estate, and there has been no attempt to encourage the establishment of a normal village community life on Papuan plantations. This is in striking contrast with the situation in other rubber producing countries. Labourers in Papua are now largely recruited from the Highlands districts where rubber is not grown nor is ever likely to be grown ; they arrive on estates quite unsophisticated and untrained and serve for 18 months. It is hardly to be expected that their standards of work will compare with those of established labour on otherwise comparable plantations in other producing countries. Taken in conjunction with the difference in the system for supervision and training of labour, the absence of the middle stratum of locally trained Native assistants, the inexperience of available labour results in standards of work and production on Papua estates that cannot be fairly compared with those in Malaya and elsewhere.

To complete this survey it is necessary to refer to the provision of technical services for the rubber plantation industry in other countries. The pattern of the application of agricultural science to the problems of growing and production of natural rubber has been very similar in each of the major countries where Hevea is grown. Whilst originally scientific advice was provided by the Government Department of Agriculture in most territories the industry demanded more. In Java and Sumatra the large plantations recruited their own specialist scientific advisers, establishing their own experiment stations for rubber as early as 1915-1916. This lead was followed by Ceylon in 1921 with the establishment of the Ceylon Rubber

Research Scheme, and in 1925 Malaya established the Rubber Research Institute of Malaya for rubber producers in Malayan territories. These Research and Advisory organizations were financed either by private contributions made on an acreage basis (Indonesia) or by a cess on rubber exports (Ceylon and Malaya). The job of the industries research stations is to investigate all problems of the production and processing of natural rubber and to provide information and advice upon such problems. The *modus operandi* is illustrated in some detail in Appendix to this report which describes the current organization of research and advisory services for the Malayan rubber industry. Besides drawing freely on the services of the research and information stations, estate companies usually employ planting advisors (who have largely taken the place of the old " visiting Agent "). These are men of wide experience and knowledge of practical developments in the industry who pay regular visits of inspection to estates and advise the management on administrative, operational and technical matters. Usually they keep in very close touch with the specialist workers at the industry's research stations and translate their work clearly to the man on the job.

In Papua as in other territories involved in the upheavals of World War II technical services to the rubber planters, the industry is not large enough to carry additional specialist services of the kind that have grown up in the larger producing countries.

Part II.

Statistics.—

In Papua as in other territories involved in the upheavals of World War II many valuable records have been lost, but the Department of Agriculture, Stock and Fisheries, has done an excellent job of re-assembly of essential data and, subject to the errors inseparable from records obtained largely in response to questionnaires, a fairly complete statement of the acreages under rubber, and production for the post-war years, was available. Principal data for the period 1st April, 1950, to 31st March, 1952, are summarized in Table II. It should be noted that these years include the phase of panic buying of natural rubber for stockpiles and the resulting " boom " period.

No details of rubber acreages in New Guinea are included in the statistics because it was found that records of plantings of Hevea and Ficus rubber in New Guinea were confused, so that it was best to omit them. No further reference to Ficus rubber is made in this report; observations on Hevea rubber in New Guinea are contained in Part V.

Rubber in Papua is grown in three, or more accurately four, fairly clearly defined regions, namely—

(i) the coast alluvial plains and broad river valleys of Western, Gulf, Central and Milne Bay Divisions, with some 9,000 acres in the Kanosia area;

(ii) the Sogeri plateau of Central Division, at 1,400 to 1,600 feet, with about 7,000 acres;

(iii) the Northern Division of Papua in—

- (*a*) the Kokoda-Yodda Valley about 2,000 acres; and
- (*b*) the Popondetta-Awala-Sangara area about 3,500 acres.

Each of these four regions has its own characteristic features which are described in more detail in the notes on the surveys undertaken, Part IV. It is to be regretted that separate yield data are not available for the Kanosia and Sogeri areas, both within the Central Division; the figures in Table II. column 4, and details in Table III. show that these two areas are responsible for the major part of Papuan production, but they do not indicate the relative levels of production in the two regions.

Generally, the overall yields per acre recorded in Table II are lower than the writer had been led to expect. In an economic survey carried out at the end of 1949 * an overall yield of 400 lb./acre/year was accepted, and was compared with a reported overall yield of 564 lb./acre/annum for Malaya. The official records tabulated in this report indicate an overall yield for Papua of 239 lb./acre tapped in the year ending 31st March, 1951, and 308 lb./acre tapped for the year ending 31st March, 1952. The apparent discrepancy can probably be accounted for by the shortage of tappers and selective tapping. Areas tapped selectively do not yield maximum crops per acre; in the effort to secure maximum output with incomplete and inexperienced tapping forces the actual production attained was no doubt a good performance. Principal yield data are summarized and compared below.

(i) Rubber Acreages and Production, Papua—1951 and 1952.
(Year ends 31st March.)

Year	Number of Plantations	Total Planted Acres	Tapped Acres	Total Yield Pounds	Yield in lb./acre/year
1951	49	24,597	17,467	4,180,262	239
1952	49	26,197	18,166	5,602,117	308

(ii) Rubber (Estate) Acreages and Production, Malaya—1951 and 1952.
(Year ends 31st December.)

Year	Number of Estates	Total Planted Acres	Tapped Acres	Total Yield Tons	Yield in lb./acre/year
1951	2,252	1,963,735	1,597,012	327,956	460
1952 †	2,252	1,963,735	1,575,606	338,323	481

For the year 1952 separate data are available for these two categories :—

(*a*) Ordinary seedlings—acres tapped 1,174,688; yield/lb/acre 363;

(*b*) High-yielding material—acres tapped 400,918; yield/lb/acre 827;

(*c*) Total, both categories—acres tapped 1,575,606; yield/lb/acre 481.

The principal figures summarized above and in Table II provide some interesting comparisons.

First, it is emphasised that the Malayan data are for the estate group only—holdings of over 100 acres—no smallholding production is included in these returns. The majority of estate yield returns also include all scrap rubber which may be estimated at 12 per cent. of total production.

Secondly, considering the 1952 Malayan figures it will be noted that average yield from old, unselected seedling rubber was 363 lb/acre/year. If it can be fairly assumed that a good deal of the scrap rubber that might have been obtained on Papua estates was not processed for sale, the comparative production figure for Papuan estates in 1952 would have been 308 plus say 10 per cent. = 338 lb/

* *The Papuan Rubber Industry.* Commonwealth of Australia, Department of Commerce and Agriculture, Bulletin No. 7, January, 1952.

Sources—

(i) Data supplied by the Department of Agriculture, Stock and Fisheries, Port Moresby, Papua.

(ii) Data extracted from Malayan Rubber Statistics issued by the Registrar of Statistics, Federation of Malaya.

† In Malaya, mature rubber in tapping is now separately classified as (*a*) planted with ordinary unselected seedlings; (*b*) planted with improved material, budgrafts and clonal seedlings.

acre/year. Thus, figures of comparative production for old seedling rubber in Malaya and Papua are close enough to justify the inference that *potential* yields of rubber plantations in Papua are not very different from those in Malaya. But, turning to data of yields of those plantations in Malaya established with high-yielding material, it will be noted that over 400,000 acres or 25 per cent. of the tapped area is planted with such material and yielded 827 lb/acre/year, nearly two and a half times as much as the old seedling areas.

A further important point, the difference between areas planted and areas tapped in Papua is accounted for by backward 1945 plantings and by obsolete old rubber hardly worth tapping on the other hand, in Malaya the difference is accounted for principally by young replanted areas most of which have a potential yield of 1,000 lb. per acre or more.

TABLE II.

Rubber Acreages and Production, Papua, 1951-1952.

(From Official Returns for years ending 31st March.

Division	No. of Holdings	Year	ACREAGE STATEMENT (1) Total planted	(2) Not in Tapping	(3) Total Tapped	YIELD DATA (4) Production lbs. Dry Rubber.	(5) Pounds per acre tapped
Western	1	1951	300	100	200	26,000	130
	1	1952	300	85	215	24,600	115
Gulf	3	1951	2,072	860	1,212	205,542	170
	4	1952	2,221	812	1,409	327,183	232
Central	29	1951	17,577	4,557	13,020	3,303,687	254
	28	1952	17,668	4,363	13,305	4,292,243	323
Milne Bay	5	1951	1,278	713	565	132,257	234
	5	1952	1,478	440	1,038	261,883	252
Northern	11	1951	3,370	900	2,470	512,776	207
	12	1952	4,530	2,331	2,199	696,168	312
Totals	49	1951	24,597	7,130	17,467	4,180,262	239
	49	1952	26,197	8,031	18,166	5,602,117	308

Notes on Table II.

Column 1.—Official returns, from which the above summary is compiled, indicate that records are based on holdings which have been worked through the year. This may account for the apparent discrepancies in Column 1.

Column 2.—Areas *Not in Tapping* may be either immature or mature, the latter being out of tapping because of shortage of labour or for other reasons. In 1952 the records show 5,998 *acres as immature,* much of this is 1945 planting that suffered from neglect as a result of the change in official Regulations for the employment of plantation labour.

Column 3.—*Areas Tapped* include areas tapped selectively, i.e., only a proportion of the trees may have been tapped owing to shortage of tappers. This is reflected in the yield-per-acre figures in Column 5, which should therefore

be accepted with reserve; they do not indicate the maximum yield per acre that might be attained with a full tapping force.

Column 5.—*Yield in Pounds per Acre* falls notably short of the figure of 400 lb./acre accepted in the economic survey of 1949.

TABLE III.

Principal Rubber Plantations, Papua, their locations and planted acreages.*

Division	Name of Estate or Holding.	Location	Ownership	Planted Acerage.
Western	Madieri	Fly River	Proprietary	405
Delta and Gulf	Ogambu	Kikori	Proprietary	542
	Kerema	Kerema	Kerema Rubber Ltd.	1,500
Central	Koitaki	Sogeri	Koitaki Pltns. Ltd.	2,358
	Itikinumu	Sogeri	B.N.G. Devt. Co. Ltd.	1,575
	Eilogo	Sogeri	Eilogo Estate Ltd.	800
	Sogeri	Sogeri	Sogeri Rubber Ltd.	720
	Subitana	Sogeri	Subitana Rubber Ltd.	600
	Mororo	Sogeri	Mororo Rubber Estate Ltd	450
	Ilolo	Sogeri	Proprietary	170
	Tahria	Sogeri	Proprietary	50
	Warisaeroa	Sogeri	Proprietary	200
	Kanosia	Kanosia	Kanosia Estate Ltd.	1,600
	Lolorua	Kanosia	Lolorua Rubber Estate Ltd.	1,280
	Mariboi	Kanosia	Mariboi Rubber Ltd.	3,000
	Rubberlands	Kanosia	Rubberlands Ltd.	1,200
	Doa	Kanosia	B.N.G. Devt. Co. Ltd.	870
	Sagarai	Kanosia	Proprietary	450
	Veimauri	Kanosia	Proprietary	500
	Aroana	Kanosia	Proprietary	183
	Moyale	Kanosia	Proprietary	114
	Robinson River	Abau	Robinson River Pltns. Ltd.	200
	Merani	Abau	Proprietary	250
	Sivigolo	Rigo	Proprietary	70
Milne Bay	Mamai	Samarai	Steamships Tdg. Co. Ltd.	550
Northern	Amada	Yodda	Proprietary	220
	Komo	Yodda	Proprietary	120
	Mamba	Yodda	Proprietary	300
	Kokoda	Kokoda	Government	293
	Awala	Awala	Proprietary	70
	Sangara	Popondetta	Sangara Rubber Estate Ltd.	2,500

Note on Cost of Production.

Most planters had studied the excellent economic survey made in 1949, published in *Bulletin No.* 7 of the Department of Commerce and Agriculture early in the year, and although the object of the present survey was concerned in the main with technical agricultural aspects of Papuan rubber production, it was inevitable that questions of cost of production and comparison between those recorded for Papua with those recorded in other countries would be raised.

From figures provided by one group of estates in Papua the writer has constructed a graph which illustrates in striking fashion the progress of increase

* Table compiled from data supplied by the Planters' Association of Papua supplemented by additional information collected on the tour.

in total cost of production over the past decade. Indicated on the same graph are the figures for cost of production obtained from the Grogan report. The additional histogram giving a broad analysis of production costs shows clearly the predominance of labour charges as the principal cost item. (Figures 1 and 11.)

The writer had neither the time nor the facilities to make a detailed assessment of production costs, but an official estimate of average costs of production was provided, against this corresponding costs from a comparable Malayan estate in the old rubber 400 lb/acre/annum category, are cited for comparison (TableIV).

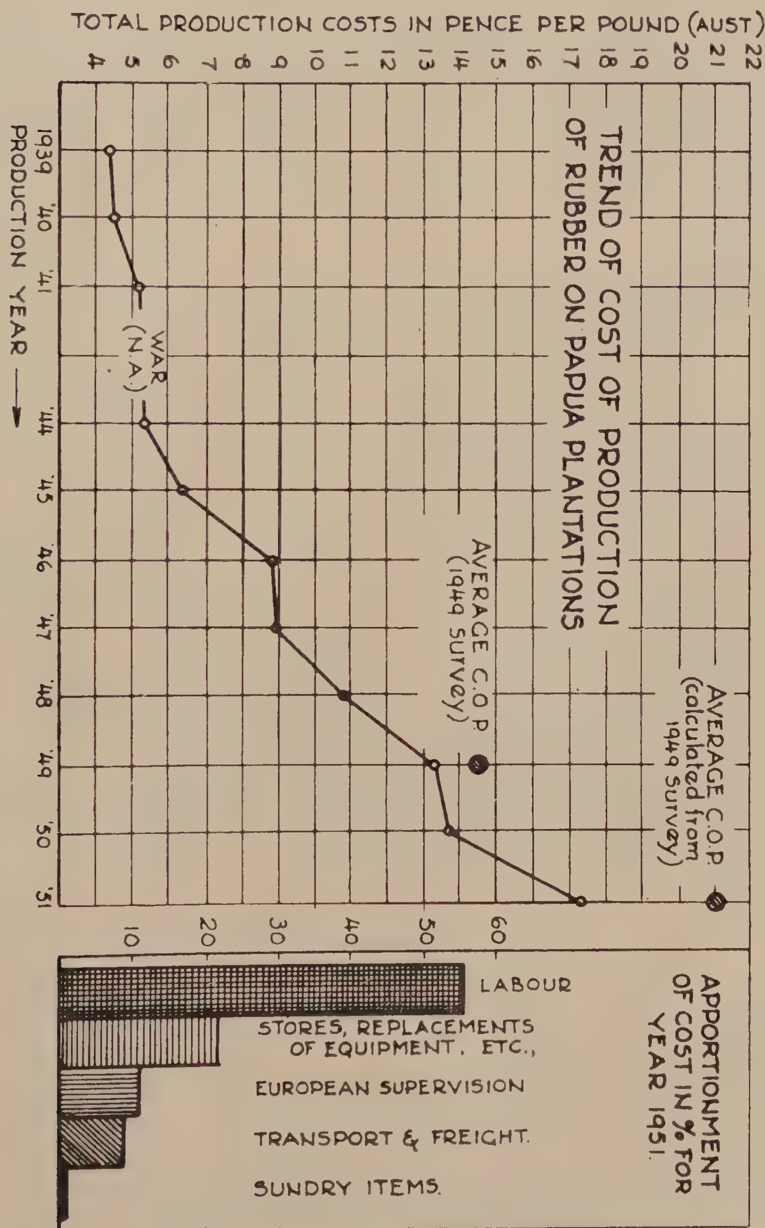


FIGURE I

FIGURE II

TABLE IV.

Comparison of Costs of Production on Average Estates of comparable Yielding Capacity in Papua and Malaya.

ITEM	Amount in Malayan Cents per pound.	
	Papua cents	Malaya cents
(1) *Indirect Charges*—		
(*a*) Proportion of general charges	2.13	15.38
(*b*) Upkeep of estate machinery and equipment	3.09	1.04
(*c*) Cultivation and Maintenance of mature areas	9.07	6.00
(2) *Direct Charges*—		
(*d*) Tapping and collection	28.38	28.18
(*e*) Processing and curing	5.20	2.98
(*f*) Grading and packing	.96	.49
(*g*) Tranport to F.O.B.	1.10	1.10
(3) *Miscellaneous*—		
(*h*) Export duty and cess	8.43	12.79*
(*i*) Replanting Reserve	1.80	....
(*j*) Depreciation (and sundries) for miscelloneous equipment	1.26	.92
Total	61.42	68.88
Equivalent Australian Currency.	21.86d.	24.5d.

* Item (*h*) Malaya, includes approximately 4 cents a pound special replanting cess which is refundable to estates.

Since cost of labour is the most important single factor, it may be worthwhile to mention some of the figures quoted by the management of the properties visited. As the basis of payment within the current provisions of the Labour Ordinance varied from estate to estate, some paying cash wages in lieu of rations, and others crediting cash to each man's account and providing full rations, an attempt was made to reduce all quotations to a cash basis consisting of overheads, including cost of recruiting, travelling, housing and repatriation, and wages per man day unit of labour. In view of the different conditions ruling in the different rubber growing districts a fairly wide range in the figures obtained was to be expected, therefore they are mentioned with considerable reserve, mainly for the sake of completeness in the record of information supplied and to provide a comparison with labour rates ruling on Malayan estates during the same period.

The relevant figures per unit of labour are (equivalents in Australian currency) :—

	Overheads	Range of daily earnings
Papuan Estates	£8 to £18	5.3d. to 6.8d.
Malayan Estates (of comparable yield)	£40 to £70 *	7.0d. to 9.2d.

* Overheads do not now include recruitment and repatriation for the system has been virtually abandoned, they include the cost of housing for the labourer and his dependants, holidays with pay, maternity benefits, land for gardens and livestock, Provident Fund contributions and other sundry items now required under the Labour Code with its post-war additions and amendments. Rates of pay are negotiated between Employers and Labourers' Trade Unions.

The tenative conclusion to be drawn from these admittedly somewhat superficial observations is that Papuan estates are in a position to produce rubber at a slightly lower cost than their Malayan counterparts. It would of course be possible to cite C.O.P. data from a Malayan estate planted partly or entirely with modern high yielding material that would be very much lower than those quoted in Table IV; the obvious inference is that a Papuan estate with equally good rubber in tapping could do just a little better.

Part III.

Survey of Plantations.

It was evident that in the time available it would not be possible to make a detailed study of more than a part of the total planted area. It was therefore decided to see as large an area as possible in order to obtain a complete picture of planting and production conditions in the Territory, and to fill in detail by a closer study of a few plantations regarded as being fairly representative in the principal rubber growing districts. Although this entailed a certain amount of selection, always a difficult problem in a survey of this kind, it was the only practicable plan.

(i) *Age of Plantings.*—

As indicated in the section on Statistics, detailed records of dates of planting and the original sources of material are not readily available, but it is clear that the major part of the total area was planted prior to 1917. There are records of fairly large extensions on the older properties between 1922 and 1928. From 1937 to 1940 further new planting was done, at least three major new developments, totalling over 6,000 acres, being undertaken during this period. In 1945 further new planting took place especially on the younger properties; over 1,500 acres of young plantings made in 1944-1945 were visited. The most progressive estates have continued, on a modest scale, to open new areas using improved planting material and methods of planting.

(ii) *Location of Plantations.*—

As in other countries where it has been planted, Hevea rubber in Papua has been grown with success on a wide range of soils and situations, from river and coastal alluvial soils at sea level to deep clay loams of basaltic origin up to an altitude of about 2,000 feet. Some areas were seen, in the aggregate inconsiderable, where rubber has failed to thrive; as a rule failure was due not so often to unfavourable soil conditions as to other clearly recognizable factors. On the whole growth of the trees compares well with that observed in other rubber growing regions, on the best soils it is excellent and compares favourably with anything seen elsewhere. The distribution of major rubber growing districts is shown in Tables II and III, and in the statistical notes; special features of the main areas are discussed in Part IV, (iii) *Planting Practices.*

(*a*) *Planting on Virgin Land.*

Planting on virgin land has generally followed an orthodox routine of felling, burning and clearing, lining and holing and planting with seedling stumps from nurseries. Small areas were seen that had been planted with germinated "Seed-at-stake" which appeared quite satisfactory, but it is appreciated that in order to be successful plantings of this kind, or with delicate young seedlings in baskets, require much more care and attention in the early stages than "stump" plantings; unless adequate field labour can be assured for the first year then "stump" planting is to be preferred.

It has been the accepted practice, with few exceptions even in the most recent plantings, to plant at a standard density of 100 to 120 trees per acre, square

planting at 20 feet x 20 feet being most usual. This has for long been regarded as giving too low an initial stand in most other countries; for example, in Malaya the generally accepted practice is to plant either bud-grafts of proved clones at 150 to 180 trees per acre, or approved clonal seedlings at 200 to 250 trees per acre reducing stands to 130 to 150 trees by selective thinning during the first 8 to 10 years from planting. Thinning in the first stage is based on growth and general observation, in the second stage on the results of test-tapping. Lack of selection is indicated in all Papuan plantings in the uneven development of the trees, particularly in older fields. It seems likely that this condition reflects the early difficulties experienced in obtaining supplies of good planting material. In the early days much seed had to be imported from distant sources, from Java, Malaya and Ceylon, losses were undoubtedly heavy and planters would be reluctant to discard any plant that reached transplantable size in the nursery. The result is evident in many uneven old stands and is probably one of the chief reasons for the failure to obtain optimum yields per acre with the material available. Unfortunately in the most recent plantings, due no doubt to the scarcity of supplies of improved planting material, the custom of planting at a low density without much elimination at the nursery stage has persisted.

As mentioned above, most planting has been on the square or rectangle irrespective of slope and lie of the land; contour planting has only very recently been attempted in new clearing work. It has been customary to plant leguminous covers in new areas, *Centrosema pubescens, Pueraria javanica, Calapogonium mucunoides* and *Dolichos hosei* (vigna) having all been used with fair success, but as in Malaya, though not on the high phosphate soils of Java and Sumatra, leguminous covers have not persisted under shade, they have been replaced by a mixed cover of soft herbs, grasses and seedlings. Maintenance is by periodic slashing of this mixed cover, including " kunai " (*Imperata cylindrica*). The latter, known as " lalang ", and regarded as the most troublesome and damaging weed in Malaya, appears to be far less vigorous and damaging to the growth of rubber in Papua.

Despite lack of special soil-conservation work, e.g., contour terracing, pitting and bunding, except on some of the oldest areas, erosion was not generally severe. Few areas have suffered seriously from the ruinous system of clean weeding, formerly practised in Ceylon and Malaya, but abandoned in favour of the system of maintenance under a mixed cover of soft grasses, herbs and volunteer seedlings controlled by periodic slashing as in Papua.

(*b*) *Replanting of Obsolete Rubber.*

Replanting of obsolete rubber has not been undertaken in Papua except on a small experimental scale by one or two plantations. This is in marked contrast to the situation on Indonesian and Malayan plantations. In Malaya on estates some 25 per cent. of old seedling areas have been replanted with buddings or clonal seedlings. Some of the most progressive estates now have up to 75 per cent. of their total acreage planted with approved high-yielding material. Yet it is certain that a large part of the old seedling rubber on Papuan estates, which is at present capable of maximum yields of not more than 300 lb. an acre, is on land capable of producing three times the crop if planted with the right material.

(*c*) *Manuring of Rubber.*

Manuring of rubber has received little attention; apart from manuring of nurseries and one example of experimental manuring on a small replanting no information on local experience with fertilizers on young rubber was available. The prohibitive cost of imported fertilizers and heavy transport costs to most of the rubber growing districts will continue to discourage the use of fertilizers, yet in connection with replanting it is essential that trials on the use of fertilizers should be undertaken. Experience elsewhere has shown that fertilizers at relatively

small rates per acre may reduce by as much as two years the time taken to bring a replanting into bearing : the cost of fertilizers has been more than fully recovered, without fertilizers it is doubtful whether some of the land in Malaya that has been successfully replanted with rubber would have been worth replanting. In the writer's opinion much of the old rubber seen in Papua is on land that would replant successfully without heavy expenditure on manuring, but experiments are necessary to confirm this.

(*d*) *Mechanization of Planting and Maintenance Operations.*

Mechanization of planting and maintenance operations on rubber plantations has not yet been developed on any appreciable scale. Clearing of land with heavy mechanical equipment was seen in one district, but the cost of such work would be quite prohibitive for the preparation of land for rubber planting. Limited experience in Malaya has generally indicated that except for very large scale operations, the use of heavy mechanical equipment is seldom justified on costs. Under Papuan conditions, assuming that replanting and new planting may be done, the scale of operations and wide distribution of plantations seem unlikely to favour the use of the types of heavy equipment needed to uproot and clear mature rubber or forest. The older and simpler methods of felling and clearing, with or without a burn, are likely to prove much less costly and in practice, quite satisfactory. On a few plantations light, rubber-tyred tractors of the Ferguson type, and semi-track units up to 35 h.p. with suitable attachments have been used with success in light clearing and cultivation work. Such units may be extremely useful in replanting operations, following felling and burning, provided that layouts and planting distances are planned to ensure smooth operation in subsequent work.

(*e*) *Other Methods of Planting.*

Other methods of planting seen included one development of special interest. A small proprietary holding of about 100 acres was being developed on land under light forest, probably secondary growth or an area from which all sizeable timber had been felled and removed. In successive years, areas of 20 to 40 acres were felled, given a light burn and cleared sufficiently to give access for lining, holing and planting. Planting was with good seedling stumps and upkeep during the first two years was mainly confined to keep the plants clear and ensuring a good getaway. Maintenance otherwise was restricted to sufficient slashing of undergrowth between the rows to keep the young rubber trees ahead of competition. As the shade from the developing rubber trees increased the undergrowth had become progressively weaker and maintenance costs were small. In one section smothering of undergrowth has been greatly assisted by the successful establishment of *Pueraria javanica.* Although the growth of the rubber had been retarded by competition of the undergrowth in the first two or three years and the period between planting and coming into production may be a year or more longer than by more orthodox and expensive methods, a very satisfactory stand of seedling rubber was being established by the method outlined and soil losses from erosion are reduced to a minimum.

Part IV.

Planting Material.

All planting prior to 1928 was with common unselected seedlings, such material is capable of yielding under average conditions a maximum of about 500 lb. per acre per annum. With a low initial stand and casual losses due to storm damage and disease, effective tappable stands have been reduced from 100 to about 60 trees per acre or less in many old fields, and average yields of not more than 300 lb. per acre can be expected from old rubber in this class.

In 1928 Koitaki Plantations, Sogeri, planted an area of 55 acres with Tjikadoe seedlings, selected material imported from Java. Since 1933 fair quantities of

" Koitaki Selected Seed " collected from the original Tjikadoe seedling planting on the Koitaki estate, have been used in new plantings. In 1934 Itikinumu Estate, Sogeri, established a small area of about 5 acres with clonal seedlings raised from Prang Besar isolated garden seeds imported from Malaya through Singapore. This block after removal of low yielders after test tapping and yield recording has provided limited quantities of " Singapore " selected seed for use on Itikinumu Estate and for sale to others.

Despite several attempts by the Department of Agriculture, first in 1934 before prohibition of export of improved planting material from countries within the International Rubber Regulation Agreement came into force, and again in 1944, when restriction on export was removed, the total area of rubber planted with buddings of proved clones, including a recent replanting of 10 acres, did not exceed 20 acres in the entire Territory.

Plantation owners in Papua, with few exceptions, have not accepted the value of budgrafts for commercial plantings and are almost unanimous in their preference for clonal seedlings. Unfortunately, no clonal seedlings of the type that can be confidently recommended for commercial planting are available in Papua ; to import them is difficult and very costly.

There can be no doubt whatever that the lack of local supplies of improved planting material has been the principal weakness of the rubber producing industry in Papua and New Guinea. In contrast with the reluctance of rubber planters to accept new material, the outstanding advances that have been made in Keravat in the production of high yielding selections of cacao, and their ready reception by planters are remarkable.

PART V.

Tapping and Harvesting.

(*a*) *Standard of Tapping.—*

Most planters will agree with the general statement that " the capital of a rubber plantation is in the bark of the trees ". The standard of the tapping operation therefore is of paramount importance and merits special attention. There is plenty of evidence of a good standard of tapping in the past, but most of this evidence is to be found in the evenly renewed bark of panels tapped seven or more years ago, prior to 1946. On those estates which have been fortunate in retaining experienced tappers, principally those recruited from the coastal districts of Papua, Rigo and Abau, and some from the Northern Division, a reasonably good standard of tapping is still to be seen. But this cannot be said for the majority of estates, who now depend largely on inexperienced labour. It takes more than a few months, even with expert tuition, to teach a tapper and a poor tapper can do irreparable damage in a few days. It is perhaps a small consolation that most plantations have extensive old areas overdue for replanting on which under a few skilled " boss boys " new tappers can learn the rudiments of their trade. Indifferent standards of tapping were however too frequently to be seen on younger rubber that will have to provide the bulk of the crop for some years to come.

Whilst these observations are severly critical, it is very necessary to record that plantation managers are doing their utmost to improve this situation, but it may be a very long time under the present system of short-term employment of unskilled labour before adequately skilled tapping forces will be available.

(*b*) *Tapping Systems. —*

Tapping systems with a single left to right spiral cut on half circumference, tapping daily for one month and resting for one month, or daily in alternate fortnightly periods, appear to be generally accepted. These are standard systems

still in general use in Indonesia though in Malaya, alternate day tapping is more usual. As regards total yields there is little to choose between these different standard systems: in Malaya the alternate day system is preferred because it gives latex of a reasonably constant dry rubber content reducing factory difficulties in coagulation and processing. In daily periodic tapping the d.r.c. falls gradually from a high level at the beginning of a tapping period to a low level at the end. Unless latex is bulked from areas in which changes from tapping to rest for different areas have been suitably staggered, variation in d.r.c. can introduce difficulties in coagulation and machining, causing variation in thickness of sheet and in the drying time in the smokehouse.

(c) *Task Size and yields.*—

Tapping tasks vary from 300 to 400 trees per tapper, depending on terrain and stand per acre. Bark consumption appeared to be about 10 inches per year with the best tapping standards, in other cases bark consumption was double this amount and wounding was severe. There was evidence of a good deal of selective tapping, the poorest yielders being left untapped especially in the older areas. With shortage of skilled tappers this is sound practice, but it means that neither recorded yields per acre nor records of yield per tapper may give a true index of the full productive capacity of a plantation (Reference the data summarized in Table II).

The average daily crop per tapper was estimated at 10 lb. dry rubber, the range being from 20 pounds per tapper on the best areas to less than 8 lb. on the poorer old areas. It was as a rule difficult to obtain data of yield per acre from any but a very few plantations, almost invariably managers spoke of production in terms of yield " per unit " of tapping labour, reflecting again the general concern to build up an adequate skilled tapping force. On several estates large areas of old rubber, mostly 1904 to 1912 plantings of low productivity, were not tapped even during the height of the " boom ", owing to shortage of tappers. There is no doubt that the shortage of skilled tappers, and the difficulties of training (and retaining them) is one of the most serious handicaps of the Papuan rubber industry.

Part VI.

Incidence and Control of Pests and Diseases.

In general, Mevea in the Eastern hemisphere has not been seriously affected by destructive diseases and pests. Apart from the severe damage to rubber trees in Ceylon by mildew (*Oidium heveae*), which causes serious secondary leaf fall, and occasional heavy losses in Malaya and Indonesia due to root diseases caused by root parasitic fungi (*Fomes lignosus*, white root rot; *Ganoderma pseudoferreum*, red root rot; and *Fomes noxious*, causing a brown rot of roots and branches), other diseases are generally of little economic importance. Hevea in Papua and New Guinea showed a remarkable degree of freedom from most of the recorded major and minor diseases and pests.

This survey was made just before the " wintering " season so that it was possible to visit a few plantations before wintering, during leaf fall, and again during the refoliation period. No trace of secondary leaf fall due to the presence of Oidium was found. This was particularly interesting and important, especially in the Sogeri area, for in other rubber growing countries, notably in eastern Java and Ceylon, where Hevea is grown at a fairly high altitude, over 1,000 feet, heavy attack of the young foliage by mildew has caused widespread damage. In Ceylon it is estimated that some 200,000 acres of up country rubber plantations have been virtually written off by Oidium. It will be of the greatest importance to try to keep Oidium and other rubber diseases out of the Territories of Papua and New Guinea by imposing strict phytosanitary regulations on the importation

of any new material of rubber or living material of any other tropical crops, from countries where rubber is grown. Other leaf diseases of minor importance, Gleosporium and Helminthosporium (Bird's eye spot), were noted occasionally on nursery material, though in general all nurseries seen were cleaner and healthier in appearance than many seen in Malaya.

Stem and branch diseases, *Ustulina zonata* and *Corticium salmonicolour* ("pink" disease) both of which, the latter especially on young trees up to the 7th or 8th year of age, have occasionally proved serious on Malayan plantations, were not greatly in evidence in Papua. No bad cases of "pink" disease were seen though a few suspect cases were pointed out.

Die-back of old trees, especially on eroded areas and in the drier Kanosia district, was common; although often associated with Diplodia the presence of the fungus was almost certainly incidental, the main cause of die-back being unfavourable conditions of soil and climate and general debility of played-out trees.

Regarding diseases of the tapping panel, "mouldy-rot" caused by the fungus *Ceratostomella fimbriata* may be severe, more evident in the Sogeri district than elsewhere, but is everywhere in evidence. The standard control treatment is by painting the tapping panels, over young renewing bark, with a preparation of tar and a tar-oil, such as solignum, emulsified by boiling with water and soft soap. Painting is done fortnightly or monthly when tasks are changed over from tapping to resting and a good measure of control is obtained. Although experience in Mayala has shown that spraying of the tapping panels with tar-oil emulsions or some of the newer synthetic fungicides may give more effective control the continued use in Papua of a smothering tar-based dressing provides a good illustration of the need to do what is practicable and reasonably effective rather than to attempt new methods with unskilled labour. Unfortunately, wounding from unskilled tapping and damage from mouldy rot generally occur together. The tar dressing in common use, whilst it smothers and checks the spread of mouldy rot also delays wound healing and retards the rate of bark renewal. There is an urgent need for a new type of dressing, possibly one based on a wound healing grease, such as V.P. 2295.C., in which a fungicide may be incorporated, to take care of the fungus and to stimulate the rate of bark renewal and wound healing at the same time. Occasional indications of black stripe (*Phytohpthora palmivora*) were noted, though it does not appear to have caused serious damage on any plantation visited. The standard treatment for mouldy rot has probably taken care of this trouble also.

[To be continued in Volume 8, No. 3, January, 1954.]

PROSPECTS FOR TEA PRODUCTION IN PAPUA AND NEW GUINEA

(Extracts from report of Mr. G. K. Newton, a Tea Expert, who recently visited the Territory at the invitation of the Commonwealth Government to report on the prospects of establishing a Tea Industry.)

BOTANICALLY the tea plant is usually known as *Thea Sinensis,* belonging to the small natural order TERNSTROEMIACEAE. There are two distinctive types, one indigenous to N. India and the other to China, the former being the stock from which natural hybrids are chiefly grown in Ceylon and India, and the bushes seen growing in Papua and New Guinea (although the seed was imported from several sources) are of the same North Indian hybrid stock.

It has been suggested seed from selected gardens in North India should be imported; this raises many difficulties and is considered unessential. The seed garden at Garaina is well established and if suggestions made in the report on that property are followed, selection (done on similar lines to the cocoa experiments at Keravat) will eventually provide suitable and ample material.

The time lag for such selection can be criticized, but from the slow rate of road development, progress of selection and communications may keep pace. To open large areas of tea unconnected with seaports by road cannot be recommended for economic reasons; meanwhile the existing supply of seed should be sufficient for the requirements of the Agricultural Department and the few pioneers who are planting small areas here and there.

Left to itself the tea plant will grow up to 30 or 40 feet, but for commercial cropping is kept pruned down, plucked regularly and not allowed to grow to a height whereby leaf cannot be conveniently removed.

According to elevation above sea level at which the plant is grown, maturity for plucking is reached at 3-7 years. From observations of the soil, and tea already growing at different elevations in the Territory, together with the fact that climatic conditions at practically all localities seem suited for tea growing, it appears safe to say bushes may be brought to plucking in 3-4 years in the Lowlands and Midland areas and say 4-5 years in the Highlands.

Tea produced from Low and Midland areas will be inferior in quality to that produced in the Highlands. Briefly the areas mays be defined, if one follows the Ceylon practice, at :—

Sea level—1,999 feet—Lowland area.

2,000 feet—3,999 feet—Midland area.

4,000 feet—upwards—Highland area.

Inversely, yields from lower elevation growth will be higher than Highland yields; an empiric figure is not attempted but, provided suitable technique is followed, there seems to be no reason why yield results similar to those obtained in Ceylon and India should not be possible.

The Territory of Papua and New Guinea is situated between the 3rd and 10th parallel south latitude and 142nd to 150th meridian longitude, the whole area being within the tropics with recorded rainfall at centres where tea is growing experimentally or may be grown with success.

FOUR-YEAR AVERAGE 1947-1951.

		Goroka	Garaina	Warangoi (Keravat)	Aiyura	Wau	Mt. Hagen.
January		1220	985	1062	969	660	930
February	N.W.	1189	1683	1021	1052	797	1654
March		1354	1002	1499	680	863	1748
April		833	1607	898	908	756	1284
May		422	814	715	459	508	813
June		84	550	840	339	355	904
July	S.E.	285	746	739	144	391	600
August		110	538	1017	86	488	1104
September		486	1250	609	538	500	719
October		610	874	909	624	502	790
November	N.W.	523	1065	950	542	750	1310
December		1143	2484	1270	591	790	1175
	Totals	82.59	135.98	115.29	69.32	73.60	130.31

Wanigela probably 150-160 ins. taken from Tufi records.

At Aiyura where accurate records have been kept for several years the annual mean temperature is 62 degrees, the coldest night temperature recorded 46 degrees, the avreage minimum 52 degrees, and maximum 71 degrees. These recordings may be taken as representative of the Highland areas between Goroka and Mount Hagen.

Generally speaking the climate is moist and atmosphere humid except at high altitudes. There is no defined winter and summer, the two seasons which are experienced being described as South-East and North-West corresponding with the periods of the year when the South-East trade winds and the North-West monsoons direct the main airflow. The South-East season prevails approximately from May to October, while the North-West monsoon flows over a period between December and March.

Tea grows well from sea level to elevations up to 8,000 feet according to distance from the equator, provided soil conditions are suitable; rainfall comes within the 100 inches to 200 inches bracket, and long sustained droughts are not a regular feature. In some tea growing areas rainfall is considerably less than 100 inches where droughts take their toll from time to time.

The tea plant is tough and will thrive on soil practically any texture; successful plantations have been established on areas ranging between light sand to stiff clays. The root system is greatly controlled by the texture of sub-soil, extending down from two to five feet whilst lateral range is limited by competitors. By a suitable drainage system deep rooting may be encouraged, otherwise shallow rooted bushes may result to suffer during dry periods.

Although tough the tea plant naturally prefers rich friable well drained loam, with a not too stiff sub-soil liable to restrict penetration of tap roots.

Before planting on a large scale is attempted, chemical examination of the soil is necessary to find out its pH value in solution.

Briefly, tea requires an acid soil with optimun conditions at pH 5.5.

Without going into detail it is sufficient to say the strength of soil acids is measured in terms of pH, the pH = 7 representing neutrality. Strength in excess of 7 denotes increasing alkalinity and below 7 increasing acidity.

During the tour soil tests were taken, proving in most cases sufficient acidity required for tea.

Although a large area of the Territory is unsuited to agriculture on account of swamp, altitude, steepness of mountain slopes and poor eroded soil, the extent of undeveloped land suited for tea production is great, in fact the more one gives consideration to the potentialities the more one realizes what resources are at hand. The climate is suitable and many areas of soil up to requirements. There are, however, two major handicaps :—

(1) Labour.

(2) Communications.

The paragraph entitled "Native Labour" amplifies limitations already manifested by the fact that of 180,000 square miles (115 million acres) only 591,000 acres are under plantation and farm products by non-indigenous ownership being :—

204,000 acres—Coconut.

19,000 acres—Rubber.

6,000 acres—Cocoa.

500 acres—Coffee.

200 acres—Kapok.

Balance 361,300 acres minor products and pastoral.

Communications, except for the road systems around the main town centres, are almost non-existent. Jeep tracks have been cut round about centres of Government control, but such tracks are not suited to commercial transport required for carrying the requisites and produce for tea estates.

Labour limitations will restrict the extent of any progress undertaken in the establishment of tea, but given adequate communications some private enterprize may be expected. Transport by air between midland and highland areas growing tea will force up production costs to an uncompetitive level. It seems to the writer that roads must come first, then private enterprize for tea plantations will be encouraged to follow.

The problem for Government is an economic and political one, bearing in mind that whatever road system is developed, the amount and type of labour available must restrict agricultural development, however, much one is able to mechanize.

Native Labour—

In order that the size of Papua and New Guinea may be appreciated in relationship to population, the attached map gives an indication of the areas from

which Native labour is likely to be available for recruitment. The Eastern and Western Highlands are the most densely populated areas, even here at only 28 and 16 souls per square mile, and of the total recorded adult male population in Papua and New Guinea approximately 53,000 are estimated to be in employment now.

POPULATION AND AREA.

	Adult Males	Estimated Total Pop.	Square Miles	Population per Square Mile.
Sepik	55,834	194,603	27,826	7
Madang	36,013	123,564	10,489	12
Western Highlands	14,055	157,181	9,725	16
Eastern Highlands	72,732	262,551	9,260	28
Morobe	40,437	174,825	12,850	14
Northern District	14,100	44,828	9,280	5
Central District	24,677	80,532	11,560	7
Gulf District	13,155	50,000	18,000	3
Southern Highlands	1,633	79,946	25,700	3
Western District	7,923	32,023	38,000	8
	280,559	1200,053	172,690	7
New Britain	20,000	85,115	14,150	6
	300,559	1,285,168	186,840	7

The figures given are current ones obtained through the Department of Agriculture, but it must be appreciated there are still large numbers of Natives uncounted; a total population of 1,500,000 may be taken as a fairly accurate estimation. The area in square miles recorded in various official publications is given at 180,000 approximately, or 115 million acres.

On the assumption that 53,000 males are already absorbed in employment, a balance of 227,559 appear available as recruits for plantations; this number includes residents of the sparsely populated districts, from which areas, it is unlikely recruits will be forthcoming, or Government encourage recruiting; in fact the policy for building up the Native population may severely restrict or forbid employment of labour from these areas.

This seems to restrict the areas from which plantation labour may be drawn to Madang, Western Highlands, Eastern Highlands and Morobe having a total male adult population of 163,237.

Provided the Natives are willing and other objections are not evident, possibly up to 20 per cent. of these adult males might be employed as tea plantation labour—say 33,000.

Tea requires large numbers of workers for successful cultivation under existing methods practised in Ceylon and India and, of the type of labour available, at least 1½ labourers per cultivated acre seem necessary.

On the estimation of such labour availability, probably the maximum area of tea which may be cultivated will be from 20,000 to 25,000 acres—in this case the limiting factor being labour.

Other industries are springing up, from which competition may be expected. With this factor clearly illustrated it is considered desirable to confine any

large scale tea plantation to areas where land is flat and routine work may be mechanized as far as possible. Mechanization on steep and broken land has been found impracticable.

TERRITORY OF PAPUA AND NEW GUINEA.

P.—Population—Number of Adult Males. A.—Area in square miles. Scale.—2 7/26—200 miles.

Forestry Notes—

NOTES ON THE COLLECTION OF BOTANICAL SPECIMENS

J. S. WOMERSLEY, B.Sc. *

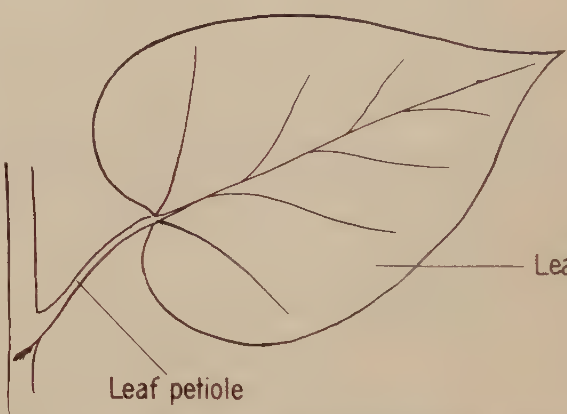
PLANT specimens for identification are frequently received by the Department of Forests Herbarium in Lae in a somewhat unsatisfactory condition. These notes have been prepared to assist would-be collectors.

A botanical specimen is most readily identifiable if it includes leaves, flowers and fruits. In the case of grasses and herbs, the entire plant including a portion of the root should be collected, but with shrubs and trees only part of the plant becomes a specimen. Care should, therefore be exercised in the selection of specimens which accurately represent the plant in such details as leaf size and shape, arrangements of the flowers, fruit, etc.

The selection of the specimens is, therefore, quite important.

In size the specimen should be selected so that it will comfortably fit onto a sheet of paper approximately 17 in. x 11 in. (See Figs. 1, 2, and 3). In this another difficulty arises. Many of our tropical plants, especially the trees have leaves of truly immense size. Some are simple, e.g., the figs, of which Figure 1 is an illustration, others are compound or even doubly compound as shown in Figs. 2 and 3.

Fig. I SIMPLE LEAF



Large simple leaves, grasses and many herbs may be folded so that the specimen fits the size 17 in. x 11 in. (See Fig. 4.) Compound leaves are best pruned as shown in Fig. 4. Make sure that a portion of the leaf petiole always remains as an indicator of the portion removed.

For reference it is necessary to number the various specimens. Each portion of the same plant should have the same number. When lists of identifications are sent out numbering facilitates reference to the collections.

Now, if you have carefully selected your specimen so that it shows leaves, flowers and fruits, and prepared it to fit on the 17 in. x 11 in. paper, it will be ready for pressing. The most useful form of press for use in New Guinea takes the form of a pair of wooden frames 18 in. x 12 in. as shown in Fig. 5. The frames are constructed of wooden slats 1 in. wide and ¼ in. thick. Substitutes which can be used satisfactorily include strong cardboard, masonite or plywood cut to size or a frame made by interlacing strips of split bamboo.

With some sort of frame then as support the specimens are placed between sheets of absorbent newsprint. One specimen between two (2) thicknesses of paper is usually enough. When all specimens are in the bundle a second frame is placed on top and the bundle tied firmly with several turns of string. It is unnecessary to place excessive pressure on the specimens.

* Forest Botanist, Department of Forests, Lae, Territory of New Guinea.

If you live in a dry area the bundle could be hung in a sunny place for a day or so. In most parts of New Guinea though, it is best to preserve the material against attack by mould. This is done by immersing the bundle—paper, specimens and all in formalin solution of approximately 5 per cent. concentration of formaldehyde. A 44-gallon drum is useful for this if no other suitable container is available. The Department of Forests has constructed for field use rectangular boxes measuring 18½ in. x 12½ in. x 12½ in. internal dimensions. The material is galvanized iron which is heavily painted within with a bitumastic paint. A fitting lid covers the specimens when in use and two (2) handles fixed to the ends, makes portage easy.

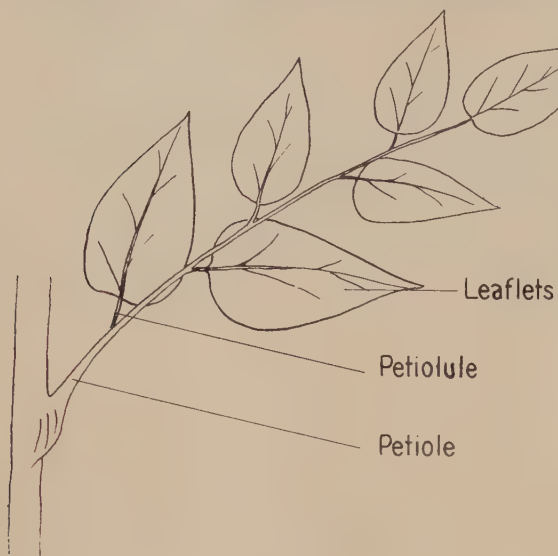


Fig. 2. COMPOUND LEAF

Specimens should be left in the formalin solution at least 24 hours after which the bundle is removed, drained and wrapped securely in sisalkraft or other waterproof paper. If the specimens have not been treated with formalin, ordinary brown wrapping is adequate.

Fig. 3. DOUBLY COMPOUND LEAF

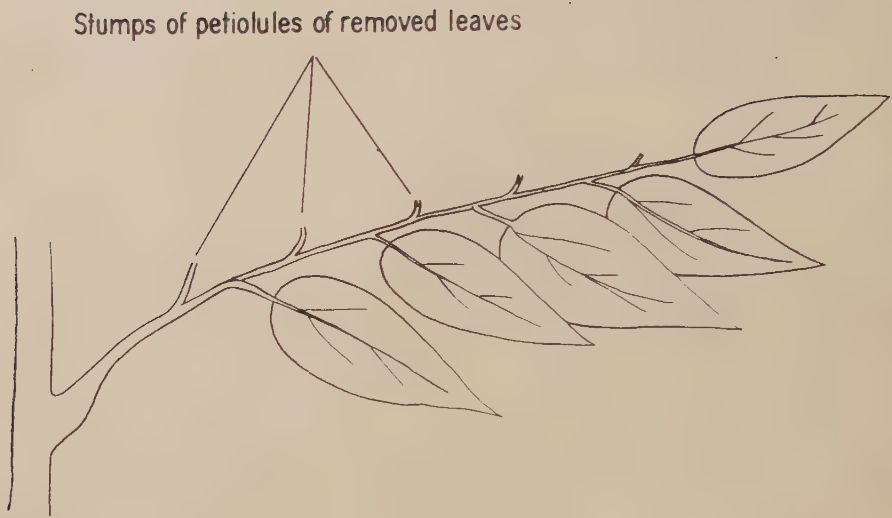


Fig. 4. COMPOUND LEAF PRUNED FOR PRESSING

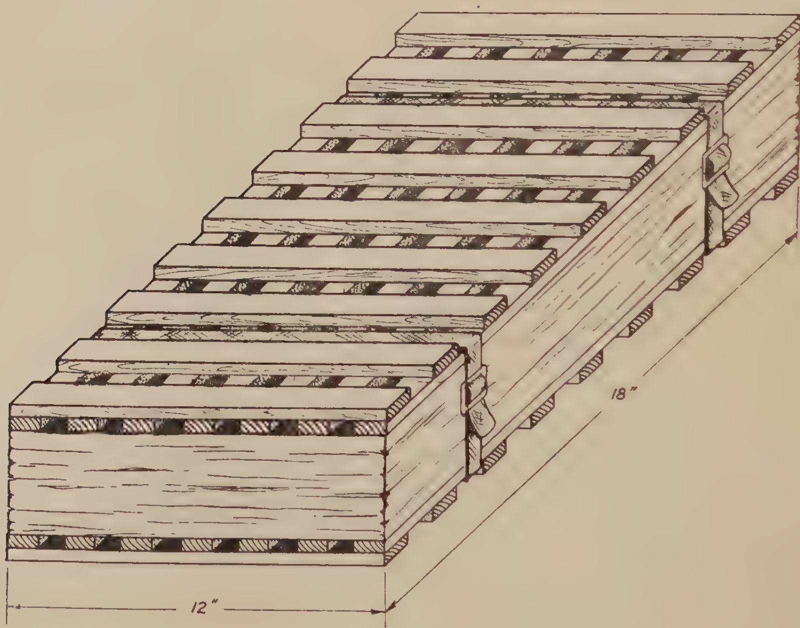


Fig 5

Press of two wooden frames and paper for drying or treating botanical specimens

The parcel should be addressed to the Forest Botanist, Department of Forests, Lae. In a covering letter, please supply details of the collectors name, place and date of collection, dimensions (approximate) of the plant, colour, scent, etc. These notes should be numbered so that they may readily be related to the specimen.

Wood Samples.

In the case of shrubs and trees, a portion of the wood is of great assistance in identifying the plant. About 6 inches of stem if the shrub or tree is of small dimensions or a block cut out of the trunk, say 6 inches to 8 inches long by 4 in. wide and extending at least 4 in. into the trunk in a radial direction. Wood samples can be bagged or boxed and sent direct to the Department of Forests, Lae. Each sample should of course be numbered with the same number as on the botanical material.

Rural Broadcasts—

(The following is the second of a series of talks prepared by the Department of Agriculture, Stock and Fisheries and currently being broadcast by Station 9PA, Port Moresby.)

COPRA MARKETING QUALITY AND PRICES

IN the previous talk the importance of the copra industry to Papua and New Guinea has been adequately stressed.

The marketing of copra in New Guinea, as is well known, is under United Kingdom contract for 10 years, which has been arranged by the Commonwealth Government with the United Kingdom Ministry of Food. The actual marketing authority is the Papua and New Guinea Copra Marketing Board, which is a continuation of the Australian and New Guinea Production Control Board, established during the war under National Security Regulations. The former operates under an Ordinance recently enforced which reduced the functions of the Board to copra marketing mainly, although Commonwealth shipping in the Territory comes under its control. Mr. Ian MacDonald, Chairman, has been associated with the copra industry for a number of years, and the actual selling, is, as far as this Territory is concerned, more a matter for his control than for the Department of Agriculture, Stock and Fisheries.

Copra prices greatly increased in post-war years, as the world shortage of fats and oils as essential foods became evident. The market price for copra became controlled under the United Kingdom contract, after 1st March, 1949. Under the contract, the British Ministry of Food undertook to purchase for nine years, all the copra produced in the Territory, surplus to Australia's requirements. Australia's requirements were not quantitatively assessed in the contract, nor was the price, but later the manufacturers there contracted to pay the same price as the United Kingdom contract price. Under the contract the United Kingdom can grant permission for specified quantities to be sold outside the contract, to countries other than the United Kingdom, and some small, but successful parcels, have been sold under this clause.

The importance of this guaranteed contract to the stability of the Territory industry cannot be under-estimated. The present price is about £65 sterling per ton, with differentials. The f.o.b. price is fixed by the Minister for Territories from time to time and varies with realization costs and costs of administration, freights, and so on, the latter having increased greatly since the war.

The copra pays duty here on a sliding scale and there is no doubt that it contributed hundred of thousands to the Territories' coffers last year. This provision for levying duty also existed pre-war.

The copra price at the beginning of the contract was fixed at £48 sterling per ton f.o.b, Territory ports, with provision for review each year in the light of the market and cost situation, and other factors, to give a maximum variation up or down of 10 per cent. of the previous year's price. There have been three upward movements of price since the beginning of the contract, and it is understood that the price for 1953 will not vary.

During and immediately after the war doubts were felt by those controlling the disposal of the copra from the Territory about the future of copra prices, and provision was made for a levy, on a sliding scale according to the price, to be made and paid into a reserve fund. The proposal was made that, when practicable, discussions would be held between the planters, the Production Control Board and representatives of the Administration and the Commonwealth Government regarding the use of the accumulated reserve fund to form the nucleus of a scheme to stabilize prices against any disastrous fall.

Between the years 1945 and 1951 the fund grew to approximately £1,000,000, the world price for copra continued high, and the contract with the United Kingdom removed, until 1958 at least, any fear of a collapse in price. Planters

pressed for a clarification of the Government's intentions with respect to the ultimate use of these funds. In July, 1951, the Minister for Territories announced that the levy (then £5 per ton) would be reduced by £3 per ton owing to the satisfactory state of the fund.

The questions of copra quality and copra price differentials are directly controlled by a separate Ordinance, which empowers the Administrator to appoint Produce Inspectors (Copra). The objective of copra inspection is to improve the overall quality of the Territories' copra. The important idea is to ensure that the copra from Papua and New Guinea will be of a standard to meet competition from that of other producing countries, in the event that this Territory no longer has the protection of a long term contract, after the present United Kingdom contract expires in December, 1957. The trade and other sources from overseas have continuously stressed the lessening in demand for smoke grade copra consequent on the increased use of soapless detergents, and the need for increased quantities of edible oils obtainable from high grade copra.

The necessity for copra inspection must be stressed. Of the copra export before the war the amount of smoke grade copra had decreased from 38 per cent. to 8 per cent. Since the war, there has been a marked and regrettable upward trend in the production of smoke grade copra. This has, in some cases, been due to causes outside the control of the planters. Even recently the percentage of smoke grade copra has increased from 34 per cent. to 41 per cent. from 1951 to the year ending 12th December, 1952, and this does not augur well for the future of the industry unless the position is remedied. It might be pointed out that the demand for copra is sustained at a high level for many reasons also there is more demand for low grades of copra in time of war, or threat of war, when the glycerine and fatty acids as by-products have more uses.

The resumption of inspection of copra in the near future, will be gratifying to those planters of both Territories, who have the good of the country at heart, and who have been requesting some such steps for some time past. The *Copra Ordinance* 1952, has been assented to and the *Copra Regulations* 1953, have been prepared to control proper inspection and grading of copra. The proposed provision of the Regulations under the Copra Ordinance were discussed with the Presidents of both Planters Associations and alterations were made on their advice and that of the Chairman of the Copra Marketing Board, to meet special requirements. Action is now being taken to appoint inspectional staff. It has been requested that such positions be filled as soon as possible as it is this Administration's wish to re-introduce copra inspection at all main ports as soon as competent men are available and appointed.

It is the Government's desire that the standard of copra produced shall be raised to the equivalent of that produced prior to the outbreak of the war and copra inspection is being resumed with that object. It is well-known that Rabaul Hot Air Copra, mainly because of the Copra Inspection Ordinance introduced in January, 1929, had an excellent name and received a premium on the world market. This premium was in operation until recently in post-war years, when unfortunately it has been lost and has meant a fall in revenue to the country as a whole.

With regard to price differentials, the question of maintenance of copra quality is linked with that of price differentials between hot air and other grades of copra and the matter is still under consideration.

The proposal to initiate an inferior fourth-grade copra, with the provision of an adequate differential to prevent undue production of such a grade, has been accepted by planters of both Territories. It has been pointed out that even a rise of 4 per cent. or 5 per cent. in the moisture content of the copra which is exported, is eliminating the advantage of any normal price premium. Both the exporters and the buyers know that the careless producer can get a

higher cash return for undried copra and thus there is no incentive to reduce the moisture content to proper proportions, while the producer gets well paid for moisture alone.

The cost of producing smoke grade copra, is considerably less than that to produce high grade hot air copra, and the cost of driers and equipment necessary to produce smoke copra is also less.

There was no system of copra inspection in Papua pre-war, but it is considered that the fact that Papuan copra from recognized plantations received a premium over South Seas Grade in later years, was largely linked with the existence of a Rabaul Hot Air Grade because substantially the same drying methods were used on plantations in both Territories pre-war.

Under the old New Guinea Copra Marketing Ordinance the general average quality of New Guinea copra, improved greatly at its inception and the percentage of higher quality hot air copra produced nearly double in about two years while reclamation claims became almost non-existent. Then Rabaul Hot Air Copra gained a price comparable with Straits F.M.S. Copra. This then sold at a premium of over £1 per ton, compared with South Seas F.M. Copra which relative to present prices would be equivalent to a premium of about £7 per ton. As early as 1935 the following remarks were made re effects of Copra Inspection in the *Agricultural Gazette.*

"In some districts when the Ordinance came into force, it was estimated that 60 per cent. of the copra being submitted for export was badly and carelessly dried. There was distinct lack of grading in the produce and the methods of curing were carelessly applied; a position which in the great majority of cases, no longer exists."

It is desired to say something of the provisions of the Copra Inspection legislation. Both the previous Ordinance and the present Ordinance provide means for Inspectors to be appointed by the Administrator with powers to pass or condem copra, or have it reconditioned and regraded for export, and prescribe the grades. All copra shipped for export from plantations or brought from plantations to main ports, shall be inspected by an inspector before shipment or trans-shipment as the case may be, and if it complies with the provisions of the *Copra Ordinance* 1952 and Regulations, and is otherwise fit for export, the Inspector shall pass it for shipment and certify its grade.

If any such copra is shipped without inspection, or if copra which an Inspector has refused for export is shipped or trans-shipped to any vessel for export, all persons responsible shall be guilty of an offence, for which a heavy penalty is provided. Provisions are made under the Copra Ordinance for persons to obtain a special permit to be obtained from the District Commissioner, subject to such amendments and conditions as that officer specifies, to purchase undried copra (green copra or green coconut meat) for purposes of trade. There is not only the aim of hot air attracting a premium, to be considered, but the necessity for the largest proportion of the copra produced to be of Hot Air Grade and thus attract a premium, which is of greatest importance, and of course this means the necessity for a great increase in improved copra drying methods on the plantations.

Copra now passing through oil crushing mills, leaves much to be desired and the extraneous materials being removed from some batches, consisting sometimes of old iron, bolts, cog wheels, shells, all types of refuse and rubbish would never have passed the Inspectors pre-war, and also damage has been done in some of the Australian mills by similar materials being in the copra. It is the intention of the Department of Agriculture, Stock and Fisheries, to take all possible action to prevent the deterioration of the position of copra quality and this will be done with the very keen co-operation of the planters themselves. It

is considered to be the moral obligation of the Government to ensure that produce is up to standard, especially having regard to the long term future of the industry.

Under the B.M.O.F. Agreement, the price margin between F.M.S. and Smoke Grade Copra, provides little incentive for the production of the Hot Air Grade. The Territory at the present time is losing at least £80,000 per annum, owing to the fact alone that no premium has been payable at all from the United Kingdom.

There is some mention that Smoke Copra can be hydrogenated and deodorised, so that a relatively high quality oil can be produced from such copra. Present enquiries do not substantiate this claim as the smoke content generally occurs in the coconut oil, and the colour is affected for purposes of high quality margarine manufacture, and the big world need is for high quality foodstuffs; further enquiries are being made.

Regarding copra price movements and cost of production, this is far too big a subject to be dealt with in this talk, but it should be mentioned that copra has provided the main source of income for both Papua and New Guinea for the last half century and this applies to both Native and European alike.

In 1941 it was found necessary to form a Copra Board in New Guinea, as prices fell as low as £4 but the average price for the year was about £12, and the planters later received a dividend. Before the war marketing of copra was largely in the hands of several big shipping companies operating in the Territory, while individual planters in some cases sold direct or through agents either in Australia or overseas. In post-war years, as stated previously, all copra has been sold through the Marketing Board.

During the war years all New Guinea plantations were closed down and only some of the Papuan plantations remained open. However, the tonnage harvested during the war from Papua, was of very great value to the strategic needs of Australia and was generally sold under a guaranteed price of about £12 per ton. It was not until after the Territory was declared as a non-operational area that price movements could again be recorded.

COFFEE GROWING

This is a text of the Rural Talk from Station 9PA given on Thursday, 20th August, 1953. It has been included in this issue because of the great interest at present being shown in coffee growing by planters in the Central Highlands area.

COFFEE is rather tolerant and will grow under a wide range of soil conditions, but it does best on a deep well drained loamy soil, with slightly acid reaction. If the correct variety is selected, it can be grown from sea level to 7,000 feet. Overseas authorities normally maintain that Robusta coffee is most suitable from sea level to 3,000 feet and Arabica varieties thrive from 4,000 to 7,000 feet. However, New Guinea experience has shown that Arabica coffee can be grown successfully at 2,000 feet. As Coffee Rust (*Hemileia vastatrix*) does not occur in New Guinea, it may prove that the higher grade Arabica coffees, grow even below this altitude.

Establishing a Coffee Area.—

In establishing a coffee area, either from virgin bush or in grasslands, it is preferable to concentrate the labour on a small area, and to clear, line, hole and establish shade over a small area as quickly as possible. This enables the shade to get away quickly without competition from the grass. Coffee may be lined either on the diagonal or on the square. The normal spacing for the crop is 9 feet x 9 feet or 10 feet x 10 feet. It is recommended that all lining be done on the diagonal, as more efficient use is made of the land under this system, and 13 per cent. more trees to the acre, are obtained. Immediately after lining, the holes should be dug, and left open to weather, until just prior to establishing the seedlings in the field. The larger the hole, the better start the seedling

gets. Holes should not be smaller than 2 feet x 2 feet x 2 feet. Immediately the holes are dug, both temporary and permanent shades should be established. Temporary shade is used for two purposes :—

1. To shelter the young plant in the early stages of its growth.
2. To smother grass and reduce maintenance cost.

Grass is most detrimental to the growth of coffee at all stages. Every effort should be made to keep the coffee area free of grass from the time of planting, until the end of the economic life of the coffee field. Coffee is a surface feeder and suffers severely from competition with grass, and if it is necessary to cultivate at maturity to control grass, considerable damage is done to the feeding system of the trees. Wise use of shade from planting to maturity, can prevent the formation of a surface mat of grass, and can reduce the need for detrimental surface cultivation to control weeds to a minimum.

In planting shade for Coffee, it is recommended that both temporary and permanent shade be planted in the lines of coffee on the diagonal. The most useful shade plant to use for temporary shade is Crotalaria, and this should be planted right up to the hole, and the permanent shade trees should be established in the centre, between the holes. By planting on the diagonal, and not straight up and down the lines, sufficient room is left between the lines of shade to permit free movement of labourers through the field. This facilitates maintenance and the planting of the Coffee seedlings later.

When the shade is sufficiently advanced (with Crotalaria, this should be about three months after planting of shade), the seedlings may be put out in the field. As the shade develops, it should form a complete cover between the holes and obviate maintenance. The only maintenance required is in weeding immediately in the vicinity of the coffee plant. As the young coffee plant grows, the shade immediately around the hole, should be cut out. Further cutting out should be carried out at any time the young plant begins to produce spindly, elongated growth.

Under lowland conditions, that is from sea level to 2,000 feet, *Leucaena glauca,* has proved a most satisfactory shade crop for New Guinea conditions. Unfortunately from 2,000 to 7,000 feet no truly successful shade tree, suitable for New Guinea conditions, has yet been proved. However, a number of species are well worth trying. Those we suggest are: *Albizzia stipulata, Grevillea robusta,* native species of Albizzias found in the Highlands, species of Acacia. It is fully recognized throughout the world, that permanent shade is required for lowland coffee. However, the position is not so clear for Highland coffee. In many parts of the world, coffee is grown between 4,000 and 7,000 feet without permanent shade, but all the evidence in New Guinea points to the necessity of establishing permanent shade for coffee, at whatever altitude it is grown. The advantages of using permanent shade for Highland coffee are :—

1. It prevents overbearing, and so prevents die back.
2. It lengthens the life of the plant.
3. It produces a more even crop.
4. It helps to control soil erosion.
5. It helps to control weeds.
6. It improves the quality of the coffee produced.

Under New Guinea conditions, coffee grown without shade will crop itself out. If a grower wishes to establish a permanent plantation, it is essential that he control the cropping of his coffee, and the only economical way to do this, is by shade manipulation. Experience will show on any property, the degree of cropping that can be permitted, without damaging the trees. Hence, in choosing permanent shade trees, care should be taken to choose trees that will stand lopping. The Department of Agriculture, Stock and Fisheries strongly advises the use of permanent shade for coffee wherever it is grown in New Guinea. A

grower should bear in mind that it is much easier to remove shade from an area, than it is to establish shade in an old Coffee area. Hence at low levels, using *Leucaena glauca*, the initial density of the stand, should be 10 feet x 10 feet; on the Highlands, when using larger species, such as Albizzias and Grevilleas, a minimum initial stand of 20 feet x 20 feet, is recommended.

Wherever coffee is grown, strong winds are harmful. Hence, in exposed areas, provision should be made for the establishment of wind breaks.

Preparation and Planting of Nurseries.—

Although shade is not necessary before Coffee seeds germinate, it is preferable to establish a canopy over the proposed nursery beds, before planting the seed. It is more convenient to have a canopy, high enough for men to work under with convenience, than a low one. Bush timber posts and bearers, on which may be placed slats, bamboo or palm fronds, are satisfactory. For ease of working, nursery beds should not exceed 5 feet in width. The ground should be dug to a depth of 18 inches to 2 feet, the soil returned in the order it was removed, and the surface worked to a fine tilth. Normally the beds are raised above the surface of the ground for drainage purposes, and paths are constructed around the beds, for ease of working. The seeds are planted 4 inches apart in rows spaced at 6 inch intervals. Depth of planting is normally about $\frac{3}{4}$ inch.

On completion of planting, it is advisable to cover the surface of the beds with straw or grass litter. This prevents damage to the seedlings during watering and protects surface from excessive evaporation. When the seedlings germinate, this litter should be removed.

During the growth of the young seedlings, shade is progressively reduced. At no time should the shade be so dense that leggy seedlings are produced.

The nursery bed should be kept weeded, but this work must be done carefully; a hand fork or pointed stick should be used.

Seedlings are normally planted in the field when 12 to 18 inches high. The period required to reach this stage of growth, depends upon the conditions under which they are grown. Normally it takes 6 to 9 months. Where bamboo pots can be obtained cheaply, coffee seeds may be germinated in the beds, and then picked out into the pots. The bamboo pots are then lined under shade, and the seedlings allowed to grow in these, until ready to go into the field. Seedlings raised in this way receive less check on planting into the field, than do seedlings raised in a nursery.

Planting into Field.—

Transferring seedlings to the field is not complicated, but certain points should receive care :—

1. The open holes in the field should be filled with surface soil some time before the seedlings go out into the field. This allows the earth to settle down prior to planting.
2. All weak yellow seedlings in the nursery, should be discarded.
3. Seedlings should be removed from the nursery with as much soil as possible adhering to the roots. Exposed taproots should be pruned with a sharp knife.
4. Seedlings must be planted firmly in the soil, and covered to the same depth as they were in the nursery.
5. If seedlings have been established in bamboo pots, the pots must be removed before the seedlings go into the field.

Coffee seedlings take about six weeks to germinate. Normally with Arabica coffee, there are 2,000 seeds to the pound. Coffee seeds should be pulped carefully and never dried directly in the sun.

NEW AND INTERESTING IDENTIFICATIONS.
PLANT PATHOGENS

Phyllosticta spp. attacking kenaf (*Hibiscus cannabinus*). The seed crop at Laloki in 1952-1953 was noted as being attacked in the late stages following flowering in March and early April. Infused patches appeared on stems and leaves during periods of high humidity and these were subsequently stippled with dark pin-head dots with the infused areas becoming necrotic. Darkened patches with a black powdery surface appearance were also noted on capsules. Specimens of leaves and capsules were referred to the Pathology Department of the Faculty of Agriculture at Sydney University and Miss D. E. Shaw of that Department reported on them as follows :—

" The leaves and capsules are infected with *Phyllosticta spp.* this being the primary pathogen. On the leaves, spore cases (pycnidia) of the fungus occur in spots which are pale green fading to brown with indistinct margins. The pycnidia are visible with a hand lens, and can be seen on the portion of the leaf which is returned. Moisture causes the release of the pycnidial contents, which are masses of 1-celled hyaline spores, 10-12 x 2.5-3.

The pycnidia occur on the calyx, but are obscured by the growth of secondary fungi. They also occur on the involucre and protected pericarp, portion of which is also returned.

Phyllosticta idaecola has been recorded on cultivated species of *Hibiscus* and *Sida,* but no further details are available as to which species of *Hibiscus* are affected. A species of *Phyllosticta* affecting Roselle (*H. sabdariffa*) has been recorded, causing spotting of leaves and petioles at Delhi, but again there is no information as to whether this species attacks kenaf.

The fungus has been isolated and is established in pure culture.

Also occurring on the calyx among other saprophytes is a fungus with black chlamydospores and black stromatic tissue. It belongs to the Perisporiaceae group , sometimes called sooty moulds, which are, in most cases, saprophytic."

The spread of the necrotic areas was arrested following on the onset of normal dry season conditions during April and no marked deleterious affects on the crop were noted. However, it is considered that this pathogen may have been an important contributor to the total loss of the seed crop in the abnormal 1951-1952 season when wet and humid conditions prevailed right through to July.

RICE PATHOGENS.

Miss Shaw also examined specimens of diseased rice plants from the Madang District. A pathogen which caused serious damage to rice crops in the coastal area at Dylup, between Madang and Bogia, was identified as *Entyloma oryzae.*

Three varieties of rice grown on the District Agricultural Station at Madang showed a leaf spotting and causal organism was identified as *Ramularia sp.*, the identification being checked, at Miss Shaw's request, by the Commonwealth Mycological Institute in the United Kingdom, and the diagnosis confirmed by Dr. Ellis of that Instituute

In a later communication Miss Shaw states that a previous record by Deighton of Sierra Leone (1937) only applied to the hosts *Oryza barthii* and *Oryza glaberimma.* The fungus apparently has never previously been recorded affecting *Oryza sativa.*

Diseased heads of rice from Dagua, near Wewak, were also submitted to the Pathology Department of the Faculty of Agriculture at the Sydney University and the pathogen in this case was identified by Dr. N. H. White as *Ustilaginoidea virens* (Cke.) Tak. The symptoms are striking brown coloured sclerotia-like

structures similar in shape to rye ergots appearing between the glumes. The disease was not causing extensive damage at Dagua and Dr. White states that it is widely distributed throughout the World and usually considered to be of little importance though fairly severe epiphythotics have occurred in Burma and the Philippines.

PHYTOPHTHORA COLOCASIRE.

Phytophthora disease of taro reached epidemic proportions in the Australia Solomons, i.e., Buka Island and Bougainville Island, in the years 1947-1948 and caused such serious damage that in some cases the Native people changed to sweet potato as a staple crop. The disease has continued to cause damage throughout the District but even at the height of the epidemic certain resistant strains were notable in Native plantings and Native growers were multiplying these.

The Annual Report of the District Agricultural Officer for 1952-1953 notes a considerable lessening of the incidence of the disease in various areas and a return to this crop as a staple by Native subsistence farmers. This is particularly the case in Northern Buka Island where there is now little evidence of the disease and big areas of taro are being planted.

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